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FIVE YEARS OF SOIL AND WATER CONSERVATION in the SOUTHWESTERN MICHIGAN FRUIT AREA 1936 - 1940

Soil Conservation Service

Benton Harbor, Michigan

April 1, 1941

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PREFACE

This report is an attempt by members of the staff of the Benton Harbor project to present a somewhat chronological story of the development, progress, and results of the project.

The Benton Harbor project, established in the summer of 1935, was the first of its kind in Michigan. Its purpose was to develop and demonstrate methods of maintaining or improving the fertility of land over a long period of years by putting into effect erosion control measures and good cropping and cultural practices. State experiment station workers and others had observed that erosion was taking a heavy toll of valuable fruit land in Berrien County. The general location of the area was the result of these observations.

The problem of the project was to develop methods of controlling erosion and conserving soil in an area devoted primarily to the production of perennial fruits. The project, containing 35,500 acres, was to serve as a demonstration area for the lake shore fruit belt. This belt consists of a strip of land extending along the eastern shore of Lake Michigan, from Petoskey to the Indiana state line. The total area includes approximately three and one-half million acres.

It should here be emphasized that five field seasons is a short time in which to develop and prove conservation practices for orchard land. Observations of the various practices should be made during the lifetime of orchards, so that resultant conclusions and recommendations may be more accurate and dependable.

ACKNOWLEDGMENTS

Members of the project staff desire to acknowledge their appreciation to various organizations and individuals for their cooperation and assistance during the five years since the project was established. These include:

Members of the Michigan State College staff who have been particularly helpful in the selection of the demonstration area, in formulating a work plan, in giving technical advice regarding numerous problems, and in cooperating on certain special studies.

The local county agricultural agent who has been active in promoting the spread of soil conservation practices and educational work to foster soil conservation districts.

The Berrien County Highway Department which has cooperated on the lake bluff erosion control project and in highway demonstrations.

Local business concerns which have loaned equipment for use in demonstration work, and Berrien County newspapers which have contributed in an educational way by publishing pictures and stories regarding soil erosion and its control.

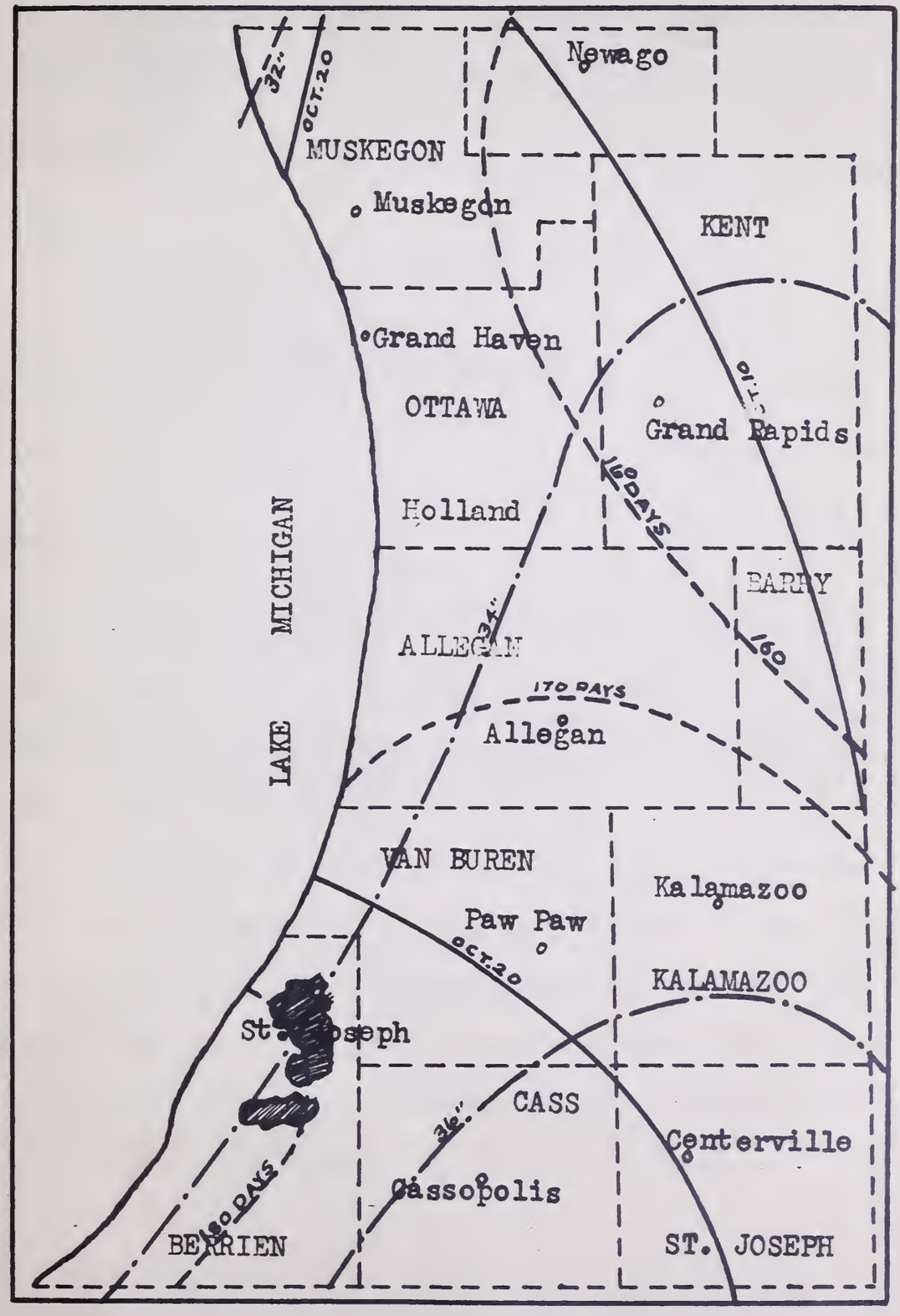
INTRODUCTION

Location and Description of the Area

The Benton Harbor project is located in the extreme southwestern corner of Michigan (Figure 1) in a rather densely populated area. The project area consists of two separate tracts; namely, the northern or Millburg area, consisting of approximately 28,000 acres, and the southern or Baroda area, consisting of 7,500 acres. The two provide a variety of soils and types of farming. Soils range from windblown sands to a heavy, silty clay loam, and farms range in size from 10 to 200 acres and vary from strictly fruit farms to the general and dairy farms common to Michigan.

The topography may be divided into three general types. One type is characterized by flat, gently undulating low plains and plateau plains, the direction of slope changing often, and shallow swales or depressions receiving most of the drainage waters. Such topography comprises approximately 50 percent of the area. A small percentage of the area is characterized by longer slopes adapted to strip cropping and contour farming. Probably not more than 15 to 20 percent is of this type. The third type is characterized by steep, complex, crumpled, choppy and pitted topography. The slopes are extremely variable in steepness, length and directions and extremes in degree of steepness. About 30 to 35 percent of the area is thus characterized.

CLIMATOLOGICAL MAP FOR SOUTHWESTERN MICHIGAN



Length of Growing Season

Killing Frost in Autumn

Annual Precipitation

Figure 1.

Most of the land is situated from 700 to 760 feet above sea level. See Figures 47 and 48 (in appendix) for a more detailed representation of topography and slopes in various parts of the area.

Climate.

Due to the proximity of Lake Michigan, the climate of the area is modified. The prevailing southwest winds sweep across the lake. Thus losses from early spring frosts are minimized since the cold winds prevent fruit buds from developing until after most of the killing spring frosts are over. The growing season in the fall is lengthened. Due to this favorable climate, fruit growing is the dominant type of farming. The average growing season is approximately 180 days, with the last killing frost in the spring occurring about April 26, and the first killing frost in the fall occurring about October 25 (Figure 1).

Unabated winds sweeping across the lake with frequent high velocities constitute a major cause of wind erosion on the sandy soils of the area. The most severe wind erosion takes place in late winter and early spring when most of the vegetation is either dead or devoid of leaves. Some wind erosion takes place in all seasons of the year.

The annual precipitation is approximately 34 inches and is fairly well distributed throughout the growing season. July and August often have less rainfall than the spring and fall months (Figure 1).

The rainfall intensity frequency data for this portion of the state as given by Yarnell (14), 1/ is shown in Tables 2 and 3 in the appendix.

Freezing and thawing takes place in the fall and late winter months, causing sloughing of gully banks and some heaving of vegetation. These, of course, contribute to erosion.

Certain erratics in climate also cause severe erosion losses. A mid-winter thaw that melts the snow and thaws out the ground for a depth of several inches with frost still remaining below this depth is an example. This condition, accompanied by intense rains, causes erosion losses in cropland and orchard, even though over-winter cover crops have been planted.

Drainage.

The drainage pattern may be described as "glacial constructional" in contrast to the dendritic pattern common in residual or other areas where the drainage system is the result of geological erosion. "Pothole" depressions and small marshy areas receive the drainage water from large upland areas. These depression areas usually do not drain into streams by surface waterways. Any drainage that takes place is subterraneous. Probably only a small percentage of the grand total of eroded material actually is carried away in streams.

1/ Figures in parantheses refer to literature cited.

Streams in general are moderately swift, carrying heavy loads of sediment only after intense rains. Stream bank cutting and flooding are of minor importance. Some difficulty is encountered by deposition of sediment in the more sluggish drainage ditches in flats that receive the run-off from upland erodible areas.

Native vegetation.

The original vegetation consisted chiefly of hardwood and mixed hardwood coniferous forest. The heavier-textured upland soils supported such species as beech, hard maple, oaks, ash, hickory, and others. Oaks and white pine were important timber species on the upland sands such as Plainfield. The species dominating on the lowland areas were maple, elm, oak, willow, and some beech, whitewood or tulip poplar. A few of the marshy areas were vegetated mostly be sedges and shrubs. Wild huckleberries are commercially important on a few sites.

Agricultural History of the Area

Forest to fruit.

The Benton Harbor, Michigan, Soil Conservation Service demonstration project area lies in Berrien County. Its history is much the same as that of the county, which in turn is closely linked to that of the St. Joseph River valley. Until late in the 1700's, the Pottawatomie Indians were sole occupants of that valley. Authentic record of the first visit of white men is the account of LaSalle's explorations on his way to the Mississippi. He reached the mouth of the St. Joseph River November 1, 1679. About 1780, the first trading post was established at the mouth of the river by William Burnett. Records for 1801 show that a part of the shipment from the trading post consisted of maple sugar.

The pioneer colonist and farmer of Berrien County was Squire Thompson, who settled there in 1823. In the early years, the county passed through the usual stages of pioneer development in forest country. Gradually, increasing acreage of woodland was cleared and brought into cultivation. With the introduction of binders and other improved machinery in the 1870's, wheat became an important crop for export.

Little prairie land existed in Berrien County, only two prairies being mentioned by early writers. Neither of these covered any of the land in the Soil Conservation Service demonstration area.

The so-called "barrens" which occupied a small portion of many townships consisted of sandy soil covered with stunted trees and vegetation. This soil was poor, but by the use of fertilizers and careful management, it has been made to produce fairly remunerative crops. These lands were found to be capable of raising certain kinds of fruit or truck crops, and in this way, some of the poor land has been made highly profitable.

Much of the county was originally covered with forests of valuable timber, consisting mainly of white and red oak, hickory, whitewood, maple, beech, black walnut, elm, ash and basswood. Many townships were almost covered with immense forests of tall, thick timber.

A most picturesque feature of landscape was presented to the first settlers in the form of "oak openings." Dotted over the county were extensive forests of large, handsome white oak trees, looking like stately parks. The trees were separated at some distance from each other; no underbrush grew between them; and a vehicle could pass through these forests in almost any direction with perfect ease.

In their eagerness to clear the land, the early settlers burned enormous quantities of valuable timber. Subsequently, the lumber industry denuded the land of the remainder. Lumbering was important for many years, but since about 1900, there remained no large tracts of virgin timber.

The first saw mills began operation during the 1830's and the earliest lumbering operations appear to have been in Bainbridge Township, a part of which lies within the project area. Extensive lumbering operations were carried on in that part of the county for a number of years around 1850. The larger mills, however, operated between 1860 and 1880. These closed down about 1885 for lack of logs.

Settlement followed rapidly after the early lumber operations, immigrants coming in from the east and south in considerable numbers shortly after 1845. Immigration was influenced by the opening of the Erie Canal and construction of the Chicago Road. Most of the land had been settled by the time of the Civil War.

Probably the first apple orchard in Berrien County was planted by William Burnnett about 1780, when he built his home on the bank of the St. Joseph River near the present site of Napier Bridge. About 1826, 200 peach trees and 100 apple trees were planted at the Carey Baptist Mission at Niles. The early peach trees were seedlings, and fruit was sold in 1837 from an orchard set four years previously. The commercial peach industry in the county commenced, however, about 1848 with a setting of budded trees. A shipment of peaches to Chicago was made as early as 1839. During the first period of this industry, the peak was reached about 1872. An epidemic of peach yellows, which started in 1868, practically wiped out the industry, cutting it to its lowest point in 1879. Recovery apparently began about 1890. The later period of the industry may well be followed through census reports, which indicate a rapid increase in the importance of horticultural crops and development of manufacturing establishments.

Water transportation played an important part in the early settlement of the county. River traffic was carried on first in flat boats and keel boats. Later, steamboats plied the St. Joseph River as far as Elkhart, Indiana, or roughly a hundred miles.

The larger boats ceased navigation about 1870. This is said to have been partly due to low water. Mr. Albert Beaton, of Benton Township, who has resided in the county for 74 years (since 1867), states that steamboats operated on the St. Joseph River to Niles (approximately 50 miles by river) until about 1870, when a large sand bar formed across the river at Berrien Springs.

A word picture of land and water conditions during the early days is given by Reber (10) as follows:

"Unbroken stretches of forest and swamp was the rule in those days. The deep snows of winter were held in the dark forests so that spring melting was a gradual process. The thick mat of leaves held water like a sponge, so that runoff through creek and streamlet was an all summer process. Hundreds of gushing springs aided in keeping up the flow of water. Old settlers speak regretfully of many fine springs which have vanished today. Many broad acres which now are in crops were then swamp land . . . . .

"These favorable conditions existed from the source of the river to its mouth so that a constant great flow of water was assured the year around. As a natural consequence, the St. Joseph River of those days was a much broader, deeper stream than the one we view today. Navigation by steamer and keel boat was possible as far up the river as Elkhart, and 'arks' and flat boats came for many miles further still."

Important changes during the early history of the county appeared to have exerted influences converging about 1870. Most of the land was settled by that time and the lumber industry was close to its peak. Wheat was becoming an important export crop and navigation of the St. Joseph River was being destroyed by sand bars. The protective forest was rapidly being destroyed, the earth was being plowed, and soil erosion was on its way.

That was only 70 years ago. Today, no commercial traffic exists on the St. Joseph River. In fact, during most of the year its navigation by canoe is difficult and can be accomplished only by making numerous portages. This would be even more difficult except for influence of power dams in keeping a continuous flow.

At a point six miles upstream from its mouth, a rough measurement was made of the amount of soil being carried by the St. Joseph River following rains of February 8 and 9, 1937. Estimated from records available for the area, the rainfall on these two days was about 3 inches. This measurement showed that approximately 47 million pounds of good earth were carried into Lake Michigan in 24 hours. This lasted about four days and is suggestive of what may be expected following severe rain storms in the vicinity.

Each spring, approximately $17,000 is spent to clear from the harbor at the mouth of the St. Joseph, the mud and sand deposited there by the river. These materials, through erosion, have been removed from this once forest-covered valley.

The situation is even more serious than this cost indicates. A dam at Berrien Springs, 15 miles inland from the harbor, forms a reservoir which acts as a settling basin for much of the materials carried from the upper reaches of the river. Sedimentation of the harbor, then, is largely by materials eroded from the northern half of Berrien County (Figure 2).



Figure 2. The harbor at St. Joseph, Michigan. Note the muddy water flowing out of the St. Joseph River into the harbor after a heavy rain, May 17, 1938. (Mich-311.)



An outsider coming into the Michigan fruit belt notices that vineyards, cane fruits and orchards of tree fruits have been cultivated up and down hill until great ditches have formed between the rows on the slopes (Figures 3 and 4). Often, the topsoil is gone and the loss in fertility is clearly evident by the size of the trees and the color of their foliage. Yet the grower has persisted in setting his fruit in straight rows, with little thought of topsoil loss.

One of the first successful peach growers in the county attributed much of his success to frequent cultivation of the trees. This became the recommended practice and even today, many local orchardists pride themselves on keeping all vegetation destroyed between the tree rows. Frequently, this is done from early spring until well into the summer and where no cover is seeded, the ground may be practically bare and exposed to erosion for 12 months of the year. There is little wonder, then, that the waters of the St. Joseph run muddy after every heavy rain.



Figure 3. Erosion in raspberries set in straight rows up and down hill. Note the numerous gullies between the rows. Some of the plants have been washed out completely, while others have been almost covered by deposited soil. (Mich-230.)





Figure 4. Erosion in a square planted orchard. This is a typical scene resulting from clean cultivation in square set orchards where no thought was given to soil conservation practices. (Mich-189.)



Factors influencing changes.

Climatic.

The change from forest to agriculture was brought about by man's desire to feed and clothe himself and his family. However, the change from general farming to horticultural crops was caused by his desire to increase his cash income. This change to horticultural crops was made profitable because the climatic and economic conditions were unusually favorable. The greatest factor which influences the climate of Berrien County and makes it favorable to the production of fruit is its location in relation to Lake Michigan. The moderating effect of the lake on the climate of Berrien County is usually realized to its maximum extent in the spring, when blossoming is retarded until the end of the spring frost period. The temperature during the winter season is likewise moderated by the lake so that temperatures low enough to cause winter freezing of fruit trees seldom occur. However, when the lake becomes completely frozen or covered with rubble ice, the temperature may become low enough to cause severe injury to fruit trees. Such was the case in 1899 and 1913. In 1917 and in 1936, little of the lake surface remained open and temperatures as low as 12 below zero were reported.

Economic.

The natural abundance of wild fruits, as well as the moderating effects of Lake Michigan on temperatures, was sufficient evidence to the early settlers that fruit could be grown here. The limiting factor in the development of the fruit industry along the lake was a sufficiently rapid system of transportation to Chicago and other markets to allow quick delivery of the perishable products.

The first shipments of fruit were made to Chicago by boats. As the value of this type of transportation and the relatively short time taken to reach the market was recognized, the people of Benton Harbor realized the need of a better way for getting their fruit and other products across the swamp lands at the mouth of the St. Joseph River to a suitable docking place for lake boats. With this problem in mind, the leading citizens promoted the building of a canal extending through this swamp land to provide means for direct shipment to the rich Chicago market.

After the canal was constructed, the fruit industry grew rapidly and apparently in accordance with the demands of the Chicago market. At first, those near the shipping points were the principal growers, then, with improved roads and railroad facilities, the production of fruit expanded over a larger territory.

Establishment of the Benton Harbor "cash-to-grower" fruit market in 1930 has been one of the outstanding achievements in marketing the fruits. Average sales of the major tree fruits on this market for the 1931 to 1938 period, inclusive, were: apples, 643,100 bushels; peaches, 520,820 bushels; and pears, 146,000 bushels. Large quantities of other fruits and vegetables have also been sold on this market, where buyers from nearly every state in the Union have congregated. Sales of approximately $25,000,000 of fruits and vegetables, up to and including 1936, qualifies it as one of the leading regional wholesale markets in the world.

There is also a large number of growers who sell direct from farm to wholesalers, or distribute their produce through cooperative organizations.

Fruit growing in the southern or Baroda area is a relatively new practice, compared to the Millburg or nothern area. Many of these farmers are now in the process of changing over from dairying to fruit farming. This change has probably been due to increased demands for fruits and better facilities for transporting the products to market.

DEVELOPMENT OF THE PROGRAM OF WORK

At the outset in 1935, a program of work was developed. It was to serve as a general guide for the establishment of conservation practices, both in a general way for portions of the area and for specific farms and individual fields on these farms. It represented a summary of the general conditions or problems existing and the practices or combination of practices that, according to best information and judgment, would conserve soil over a long period of years and be economically feasible.

To formulate the program of work, it seemed desirable to make a general physical and economic inventory of the area.

Preliminary Studies

Reconnaissance conservation survey.

This type of survey represents a general land inventory. Features mapped are: Soil type, slope combinations or topography, erosion conditions and the type of cover. General areas were found where the characterizing slopes were about 15 percent, the soils medium textured sandy loams with sandy clay substratum, erosion severe on most slopes and most of the land planted to perennial fruits on the square system. It is obvious that extreme types of conservation measures would be necessary on such sites. Other areas, comprised of drouthy sands with undulating topography, did not have severe water erosion. However, wind erosion is of major importance. Practices for such an area must be designed to control wind erosion and increase the humus or organic matter in the soil, which will improve the fertility and reduce drouthiness. Thus, it is apparent that the practices needed to conserve soil are determined primarily by the physical features of the land and the type of farming practiced.

A duplicate of the general conservation survey map, with legend and summary of results, is shown in Figures 47 and 48 and in Table 4 in the appendix.

Economic survey.

To determine the economic feasibility and implications of the proposed erosion control and land use program for farming within the area, it was necessary to determine the type of farming and economic factors relating to type and management and to analyze these factors in relation to the proposed program. To accomplish this, a preliminary survey of the economic and physical factors was made and data compiled from 40 typical farms in the Millburg area. The conclusion reached in this analysis was that erosion control and better land use practices were essential to successful permanent farming. The results of this survey were incorporated as part of the project work program.

Program of Work

The foregoing pages contain some information from the project work program, developed and submitted for approval during the winter of 1935 and 1936. For the details of this program, the original "Project Work Program, Soil Conservation Service, Benton Harbor Project" (unpublished) may be consulted.

Activities Facilitating Execution of the Program

Education.

Educational work in the early period of the project consisted primarily of attempting to teach the public to recognize erosion and to accept it as a menace to the production capacity of fields and farms.

One of the first steps in familiarizing the local citizens with soil erosion, consisted of meetings within the project area, with the cooperation of the Berrien County Agricultural Agent and members of the State Extension Service staff. The primary purpose of these meetings was to make farmers conscious of erosion and to give a brief description of the objectives of the Soil Conservation Service.

News releases to local daily papers were used frequently and occasionally, items of general interest were released for use in periodicals having a wide distribution throughout the state.

Exhibits were prepared for use at county agricultural fairs, school fairs and farmer meetings at Michigan State College. These consisted of enlarged pictures with short descriptions and a model farm showing the old and new methods of farming as they were actually being put into effect on a local fruit and livestock farm.

As the work progressed and people began to realize the seriousness of erosion, more time was spent conducting tours to show methods of control. Other educational activities also began to stress control methods more and more as they were proved effective and practical under actual farm conditions.

Conservation survey.

The detailed conservation survey was similar to the reconnaissance or general survey previously referred to, in that the same factors were indicated. However, it differed in detail. The former was completed for the purpose of portraying a general picture of the area to facilitate the development of the project program or guide. The latter was used as a basis for detailed farm planning.

Aerial photographs, scale 1" = 500', were used as base maps in the northern or Millburg area. The southern or Baroda area was mapped by the plane table method, using the same scale. A detailed summary of erosion and slope conditions of the project was not completed. However, a general picture of such conditions can be obtained by referring to the reconnaissance soil conservation maps (Figures 47 and 48) in the appendix.

The detailed picture, as presented by the conservation surveys of individual farms, illustrated that present farming methods were not maintaining the fertility of the land on many farms. This was especially true of sloping areas on which water erosion was severe and on sandy areas conducive to wind erosion. It definitely indicated that in many instances, land was being used improperly and that erosion control practices were lacking on most sites.

Economic survey.

A survey of certain economic factors within the project area was made by obtaining information concerning these factors from 60 farms selected at random throughout the area. The survey report showed, among other things, that farming was of the intensive horticultural type, farms were small and investments high, improper land use and erosion were common to both high and low income farms and that although earnings were not submarginal on the average, they were not as large as might be expected from the intensive use to which land, labor and capital were put.

ESTABLISHMENT AND OBSERVATIONS OF EROSION CONTROL PRACTICES

The application of erosion control practices to land under general farming conditions is being demonstrated in many parts of this country. However, use of such practices on fruit land in this project area has been limited. Hence, the establishment of those practices in orchards on this project has been made with limited experimental background. Because 45 percent of the land under cooperative agreement on the project is given over to the production of perennial horticultural crops, an excellent opportunity was afforded for the observation of soil conservation practices on fruit land under various conditions.

While the field observations given in this report may not seem to be in accord with closely controlled experiments, it should be borne in mind they represent a fair cross-section of what was found in the field. For example, seedings are frequently made too late, or under adverse weather conditions which greatly influence their survival and entirely reverse the results that would have been obtained under controlled experimental conditions.

Fruit Land

Both vegetative and mechanical means have been utilized in establishing erosion control on orchard lands. In laying out new orchards, plans may be made for the use of those control methods considered to be the most practical and effective for the particular kind of fruit and site being considered. The application of control practices to established orchards, however, is modified somewhat by various influences and, consequently, the following discussions concerning individual practices treat them, in a number of cases, from the standpoint of both new plantings and plantings already established.

Sod in orchards.

Vegetation and vegetative matter are generally conceded to be the most economical and most efficient methods of soil erosion control. In adapting vegetative cover to orchard lands, two things should be borne in mind. First, that any vegetation growing in an orchard is competing directly with the tree for plant food and moisture, regardless of the soil type. Second, that numerous methods can be used to cut this competition to a minimum, control soil erosion and grow good fruit.

The competition for plant food can ordinarily be taken care of by the increased application of commercial fertilizer, or barnyard manure where available. The problem of handling moisture competition is somewhat complicated. Various workers (7) have reported on the wide range in moisture retaining ability of different soil types. The sandier soils are found to be the least retentive and the loams and clays the most retentive of moisture. It is obvious, therefore, that with a heavy sod of equal density on both types of soil, moisture competition would likely be much more serious on the sands than on heavier soils.

There are at least two methods of approach to this problem of moisture competition. The first and perhaps the most noteworthy solution is proper land use; that is, crops with the least moisture requirements should be grown on the land which has the least ability to supply moisture. While this is the logical method of handling new plantings on open land, it is of comparatively little immediate value in solving the problem where the land is already set to perennial fruits. When old established orchards or small fruits are removed, the area can be utilized to obtain any desirable adjustments in land use. The second method of approach is concerned with the various methods of sod management.

Pome fruits.

The apple and the pear are the most widespread of the pome fruits in the project area. Of these two, the apple is by far the more common. Therefore, statements made herein will pertain largely to apples.

It is well to mention here that the average apple grower has regarded sod, as it has been handled in the past, as making too much competition for moisture to warrant its extensive use. Perhaps growers have been justified in this belief when some of the available production figures are considered.

According to Wright and O'Brien (13) the average production of tree-run apples in this area was 184 bushels per acre in 1935. Estimates by the growers for the two previous years show this figure to be about 10 percent above the average yield for those years. Figures presented by Gaston (4) show that, for a 4-year period in southwestern Michigan, 34.2 percent of the cull apples were culls because they were too small. Of the orchards used in the two studies referred to above, some were in sod, but most of them were clean cultivated. The natural deduction is that if these yields are the best that can be obtained with clean cultivation, any additional competition for plant food and moisture resulting from the use of sod would further complicate the situation.

However, one of the factors to which too little attention has been given is the volume of soil and moisture losses due to run-off. If 15 inches of rain fell on an orchard, it has generally been assumed that it would all be available to the trees. It has also been assumed that if manure were applied, say at 20 tons per acre, all the plant nutrients contained in this manure would be available to the trees. In view of the number of orchard sites where the fruit trees are gone and the site has been destroyed for further cropping (Figure 5), it is obvious that these assumptions are fallacious. In fact, where orchard sites have been destroyed by clean cultivation, the land has been sold in the form of fruit.

Investigations on the Benton Harbor erosion control demonstration plots, carried on for 43 months, indicate that of the total rainfall, moisture losses resulting from run-off, up to 29 percent may be expected on a Hillsdale sandy loam soil, with 14 percent slope, when clean cultivation is practiced up and down hill. Along with this moisture loss, valuable topsoil and plant food were lost to the extent of 471 tons per acre, or at an annual rate of 132 tons per acre. An adjoining plot, seeded to grasses, under identical conditions, lost 3.5 percent of the total rainfall and 0.22 ton of soil (soil loss occurred during the year of seeding grasses). A third plot, with complete straw mulch, started a year later, at the same location, lost 0.5 of 1 percent of the rainfall for a 31-month period, with no soil loss.



Figure 5. Fruit site in Coloma Township, Berrien County, destroyed through clean cultivation and wind erosion. This site was brushed preparatory to reforesting in 1936. (Mich-92)

Stone fruits.

Sod has been used to some extent in stone fruit orchards. However, no large acreages of cherries, plums or peaches had been in sod when the Benton Harbor project was started. Two peach orchards in sod outside the area gave some indication that it might be possible to maintain peaches in sod (at least on critical slopes) where the soil cannot be satisfactorily maintained under clean cultivation.

On all cooperating farms in the project area, there was a total of 224 acres of orchard in perennial cover before agreements were worked out. This figure covered all types of orchards. However, there were no peaches in sod on these farms. After agreements were worked out for all farms, the cooperators had agreed to sod enough additional orchards to make a total of 995 acres. As of January 1, 1941, 910 acres of sod cover were in effect. Of these 910 acres of orchards in sod, 72 acres were peaches on 20 different farms. This includes both old peach orchards, portions of which were put into sod to save the site for future plantings, and young orchards which were clean cultivated along the tree rows. These orchards have not been in sod long enough to be able to make general recommendations at this time. However, a few observations will be given here.

During the last four years, it has been possible to grow good, young peach trees in sod on light, sandy soil (Coloma loamy sand) with the available rainfall. These trees were in alfalfa and grass sod with a 4-foot strip cultivated along each side of the tree row (Figure 6). During the first two years, the alfalfa was cut for hay. In the third year, it was cut and left on the ground. This practice has also proved satisfactory on heavy ground. Trees planted in 1938, in an alfalfa sod, on a medium heavy soil (Hillsdale sandy loam) have made a good growth. They were given a little mulch of barnyard manure and straw as soon as they were set.



Figure 6. Contour cultivation. Four-foot cultivated strip along one-year old peach trees set in alfalfa and grass sod on the Roy Butzbach farm, Bainbridge Township, Berrien County. (Mich-489)



A 2-year old peach orchard was seeded to grass in 1936 on heavy soil (Miami silt loam) having on the average of 50 percent of topsoil removed by sheet erosion and occasional shallow gullies, similar to that shown in Figure 7. The slope on this land ranged from 4 to 7 percent. Seeding was made to save what soil remained on the site. The trees made little growth the first year after seeding. The second year, a mulch of red clover hullings was applied around the trees and since that time, they have made a fair growth. However, all the trees in the block are smaller than they should be at their age. Where most of the topsoil was gone, the soil loss has been reflected directly in growth of the trees and color of the foliage. The trees have a stunted appearance and the foliage a yellowish cast, indicating a nitrogen deficiency.

Conclusions.

The use of vegetation in orchards is essential for soil erosion control.

The sod in the orchard, as well as the tree, should be fertilized.

In dry years, living vegetation may cause serious competition for moisture with the tree.

The use of mulch under the trees will help to eliminate this competition.

Various methods of managements should be worked out to cut to a minimum, moisture competition with the tree.

Sod and mulch.

Although complete sod in orchards has been questioned by the majority of growers in the past, many have considered a sod and mulch method of management with some favor. Mulch here means a layer of dead vegetative matter placed under the limb spread of the tree, thick enough to kill out any vegetation growing there. The value of mulch has generally been assumed to be due to its ability to reduce evaporation and eliminate moisture competition under the limb spread of the tree where a large percentage of the tree roots are located. It would seem, from the run-off figures given, that this assumption is substantiated by the difference of 3 percent more run-off on the sod plot than on the mulch plot, as previously mentioned.

A 5-acre orchard of apples with peach fillers, set 18 by 20 feet, was seeded to grass. The mixture consisted of Kentucky blue grass, Canada blue grass, smooth brome grass, orchard grass, red-top and hairy vetch. In addition to this, biennial white sweet clover was added for bee pasture. The seeding was made late in June, 1936. The season turned off dry and the orchard grass and sweet clover were about the only plants that survived. During the second year, the sweet clover was killed out by mowing. The principal cover in the orchard on January 1, 1941, was orchard grass.



Figure 7. Severe sheet and slight gully erosion. It is erosion of this type that is causing extensive soil losses, and finally fruit site abandonment in Berrien County, Michigan. (Mich-232)



The orchard was set on heavy soil (Miami loam). About three-fourths of the land in this block has a slope of 4 to 7 percent, with 50 percent of the topsoil on the average being removed by sheet erosion. The remaining one-fourth is the same type of soil, with a slope of from 0 to 3 percent, and less than 25 percent of the topsoil removed. In the winter of 1937, the owner bought and hauled in about 40 tons of straw, which was used for mulch under the trees, as shown in Figure 8. In 1938, about four tons more of straw were added. In 1939, the second cutting from three acres of spoiled alfalfa was added.

In the spring of 1937, the normal application of fertilizer (ammonium sulphate) was added under the limb spread of the trees. In June, a yellowing of the peach foliage was noticed and one pound of sodium nitrate was added. After the next rain, the trees responded immediately.

Apparently, in its decay, the straw had drawn upon the supply of nitrogen intended for the trees and this shortage was reflected in the foliage of the peach trees. No such indication was reflected either in the foliage or growth of the young apple trees. Length of new growth on the peach trees was not as much as ordinarily desired. However, sufficient fruit buds set to make a good crop in 1938.



Figure 8. Sod and mulch orchard. 5¼-acre sod and mulched apple and peach orchard in 1936, the summer after seeding down. Straw applied at the rate of about 8 tons per acre, trees set 18 by 20 feet. (Mich-253)



In 1938, from 1 pound to 1.5 pounds of ammonium sulphate were used under the limb spread of each peach tree. In early June, 1 pound of sodium nitrate was added per tree. The trees made a good growth and a fair crop of peaches was harvested, although a severe freeze occurred on the 11th and 12th of May. Enough fruit buds were set so that it was necessary to thin heavily in 1939. The 1939 fertilizer application was the same as was used in 1938. Rainfall was 5 inches more than normal from April 15, 1939, to September 15, 1939. Asked about the peach crop on this block, the owner said: "Of all the peaches I grew this year, the ones from this sod block were the best colored and packed about one-fourth inch larger than those from the clean cultivated orchards."

In 1940, 1.5 pounds of ammonium sulphate were applied under each tree late in March. Owing to frost injury, the crop was very light and consequently, no further application of fertilizer was made during the year. Fruit coloration in this orchard was again better than in orchards which were cultivated.

Conclusions.

While in the preceding cases the peaches have not been in sod long enough to draw any definite conclusions, a few observations have been made:

From the wide difference in the success of orchards on soils of similar type and erosion classification, it is obvious that management has a great deal to do with the success or failure of such plantings.

Young trees, 1 and 2 years old, have made good growth where they have had a good mulch around them.

Growers using the sod and mulch system with peaches, should start it in a small way until such time as they have learned to handle the system under their particular conditions.

This practice can be used on sites already planted and eroding badly, to hold the soil until these sites can be put to their proper use.

Where straw mulched, additional nitrate fertilizer, preferably in a quickly available form (sodium nitrate), should be applied during the summer months as the trees (by color of foliage) indicate need for it.

Other stone fruits will ordinarily fall in between the apple and the peach in their response to treatment under sod or sod and mulch.

To aid in the control of rodents, mulch should be kept at least 12 inches from the trunks of trees.

More observations are needed on the use of sod and sod and mulch in peach orchards.

Modified sod in orchards.

Pome fruits.

Soil erosion control in established fruit lands is a matter of doing the job with the least amount of vegetation required. Because not enough mulching material is available at a reasonable price to mulch all of the locations where it is desirable to seed down orchards, other methods of controlling the sod have been tried. Modified sod, similar to that used in Pennsylvania, was tried in a limited way. It has proved satisfactory to date. This method has been tried both on mature apples and pears. Two examples follow: First, a mature pear orchard on heavy soil (Miami silt loam) with an average slope of 4 to 7 percent, and on the average 50 percent of the topsoil removed by sheet erosion; and second, a 14.6-acre mature apple orchard on medium to heavy soil, about one-half of which is Hillsdale loam with a slope of from 5 to 7 percent and on the average 50 percent of the topsoil removed by sheet erosion. The remainder is Miami silt loam, one-half with a slope of 4 to 7 percent and one-half with a slope of 7 to 12 percent, and all having on the average of 50 percent of the soil removed by sheet erosion. The pears have been in sod for a number of years. The apple orchard was seeded in 1938. In the pear orchard, the modified sod system of management was used in 1938, 1939 and 1940. In the apple orchard, it was used in 1939 and 1940.

The mowing machine was replaced by a disk weighted down, set fairly straight, and operated across the major slope. The sod was disked during the growing season, about the time the grass would normally be mowed.

This method of disking leaves the grass chopped and mopped down, producing a trashy surface. Many of the grass plants are partially torn from the ground. Such a roughened, trashy surface is ideal for absorbing water and preventing soil losses. After a few good rains, the grass becomes so green that one hardly knows the field has been disked.

The treatment in neither of these orchards has progressed far enough to be able to say what the final outcome will be under drouthy conditions.

Stone fruits.

The modified sod system of management was tried only in a limited way with stone fruits. A 1.8-acre mature sour cherry orchard in sod - mostly orchard grass - was treated in 1939. This orchard was on heavy soil (Miami silt loam) with slopes ranging from 4 to 12 percent and on the average 50 percent of the topsoil removed by sheet erosion. About the time the grass headed out, the orchard was disked. This was accomplished in a manner similar to that described for apples and pears. A short time after disking, a good rain came and the grass started new growth immediately.

Conclusions.

There are a number of suggestions pertaining to the use of the modified sod system which seem appropriate:

Good judgment must be exercised in the amount of disking to give the grass in order to maintain the proper amount of vegetation, but not destroy it.

Disking may be done any time that competition for moisture between the grass and the tree appears to become too keen.

Any of the native grasses appearing in orchards can be kept within bounds in this manner.

With this method of management, the varying amount of cover required by the different soil types, slopes and erosion, can be met.

To secure best results, the last disking must be across the slope.

If the ground appears too rough for spraying operations, this can be partially eliminated by use of a cultipacker, across the slope, after disking.

The work on stone fruits has not been in progress long enough to warrant conclusions. Enough of the practice has been observed, however, to make it appear that additional observations and trials should be made on a more extensive scale.

Alternate middles in sod.

The practice of "alternate middles in sod" between the tree rows in orchards as a means of erosion control, has been used in a few cases on this project. With this practice, it is intended that the middles not in sod will be cultivated during the spring and part of the summer and then seeded for over-winter cover. At varying time intervals, depending on the soil and density of sod cover, the cultivated and sod strips will be rotated. New sod should be established in the cultivated middles before the old sod is broken.

Alternate middles in sod were established in only six orchards. Two of these are now in complete sod, one through discontinuation of cultivation and the other through seeding. In the latter case, the slope is approximately 10 or 12 percent and severe rilling occurred in the cultivated strips. The direction of middles has, in all cases, been across the major slope. In some cases, where there is a change in the direction of the major slope, the direction of cultivation has been correspondingly changed, within the orchard.

In two orchards where both "alternate middles in sod" and "sod buffer strips in the tree rows" were used, the owner plans to extend the areas in alternate middles to include the remainder of both orchards. Thus his preference of the two practices is indicated.

While alternate sod middles have not been used to such an extent as to warrant the making of detailed recommendations, the following observations should not be overlooked. This practice has failed to stop erosion on the heavier soils in this project where the slopes were greater than 8 percent. However, it should be noted in these cases that erosion on the slopes ranged from 50 percent of the topsoil removed by sheet erosion, to as much as 87 percent in some instances. The ineffectiveness of these middles was due to the failure of the grass to become quickly established on badly eroded soil. Alternate middles in sod have afforded some control, but this has not been sufficient in some cases. On gentle slopes and open soils, control by this practice has been satisfactory. Although not tried on heavy soil on the more gentle slopes (because of the satisfactory performance of 4 to 6 foot sod buffer strips in the tree rows) under similar conditions, it is believed alternate sod middles would perform a satisfactory job of erosion control there, in conjunction with cover crops on the cultivated middles.

It should be borne in mind, when considering the use of the practices mentioned above, that they are only what might be termed "stop gaps", to be used in square planted orchards. The most erosion can be controlled with the least amount of vegetative cover if the tree rows are on the contour. In other words, a minimum amount of vegetation in the form of sod buffer strips in a contour orchard might be more effective in the control of erosion than alternate middles in a square planted orchard under identical conditions.

Conclusions.

They should cross the major slope as nearly on the contour as possible.

They have not controlled erosion satisfactorily on badly eroded, heavy soils where slopes were over 8 percent.

Improved methods of establishing grass should be used, such as a light mulch, especially on badly eroded sites.

They have worked well on the sandier soils.

More erosion control can be accomplished with less vegetation, if the rows are on the contour.

Sod buffer strips.

Permanent sod buffer strips in the tree rows were originally intended for use as a means of erosion control in orchards set on less severe slopes and on drouthy soils. It was felt they would be insufficient for satisfactory control on severe slopes, but would furnish about the maximum amount of vegetation permissible without serious competition with the trees for moisture on drouthy soils. Fortunately, the more drouthy soils are the least erodible and it is possible to control erosion on them with less vegetation than on the heavier soils. In practice, however, they have been used under somewhat more variable conditions.

Development of good sod buffers in orchards already established has not been so satisfactory as desired. The chief obstacle has been the custom of cross cultivation to eliminate all vegetation in the tree rows. In some cases, seedings were made but failed and no second attempt was made to establish a sod. In others, no seedings were made and native vegetation alone was relied upon. These were usually cases where cultivation was discontinued except in one direction, the rows being left undisturbed. Where the soil is good, such a system will provide a fairly satisfactory vegetated strip, but in the places needing control most, the soil is usually eroded and grows little cover, unless seed and fertilizer are applied.

In some new orchards, set according to cooperative agreement, a plan has been followed by which young peach trees are cultivated for about three years while a soil building program is being carried on between the rows. The cultivated area forms, in the tree row, a strip which is gradually widened as the trees grow larger. When the orchard comes into bearing, cultivation is transferred from the rows to the middles and the strips are permitted to sod over in the tree rows. Many of these young orchards are set on the contour and consequently, as the sod develops, contour buffer strips will be formed. The first contoured orchards have not yet come into bearing, consequently, most of the contour sod buffers are still to be established.

Well sodded buffer strips in the tree rows have been effective in checking erosion (Figure 9). Even on the steeper slopes, where they were used in square planted orchards and became well established across old waterways, they prevented severe cutting through the rows.

One grower had used buffer strips in a peach orchard for a number of years before becoming a cooperator. He prefers sod strips in the rows to sod in alternate middles between the rows.



Figure 9. Sod buffer strips developed in an established orchard. Although not on the contour, these strips have served effectively in checking soil erosion on this slope. (Mich-182)

Another grower said: "Mother didn't like the looks of those weeds and grass in the tree rows and wanted to turn them under this spring, but I suggested leaving them another year. A heavy rain came the following week and we were certainly glad to have those buffer strips."

On this project, sod buffers in orchards are commonly planned to be not less than 4 feet wide. Narrower widths seldom have been recommended. In some cases, in square planted orchards, direction of the strip changes in order to be across the major slope.

As long as cultivation is practiced between the tree rows, some soil movement will occur. With the sod buffer strips catching most of the moving soil, a bench effect will eventually develop and unless sod is maintained in the waterways, cutting will occur in them below each strip.

Sod buffer strips in the tree rows have not been used on the project in a sufficient number of cases to make definite recommendations with regard to their application on different soils, degrees of slope and amounts of erosion. It may be said, however, that even thin stands of annual grasses left in the rows have provided considerable erosion control and where good sod buffers were established, the control provided was surprisingly good.

Conclusions.

They should be used across the major slopes, as nearly on the contour as possible.

They are best used on gentle slopes, where sandy soil conditions exist and where the maximum deviation from the contour is less than 3 percent.

Buffer strips are difficult to establish on badly eroded, heavy soil.

The benching effect caused by buffer strips is more pronounced on the sandier soils.

Buffer strips should not be less than 4 feet wide and are most effective when used in contour orchards.

Cover crops in orchards. (Annual, biennial and perennial.)

When the Benton Harbor Soil Conservation project was started in 1935, clean cultivation was the general practice in orchards. Some winter cover was being used, but from farmer reports, this was not as common as it had been a few years previously. Occasionally, an orchard (pear or apple) had been permitted to remain in sod. Such orchards were located on the medium and heavy textured soils.

Owing to the climatic and economic conditions peculiar to southwest Michigan, many orchards are located on slopes which, under general "land use" recommendations, should be removed from cultivation. This fact modifies the application of soil conservation practices recommended in areas of general farming.

Different problems are presented by orchards already established, as compared to those being set out. The difficulty of constructing terraces in old orchards makes vegetative cover the most practical method of erosion control. In new orchards, mechanical methods, such as contour planting and terracing, may, when combined with vegetative cover, offer the best means for control.

Cover in orchards, as used in the area, may be classified as annual, (winter or summer), biennial and perennial, based on the life habits of the plants used.

Annual cover.

Winter cover is more commonly used than summer cover, although the latter is often used in young plantings and during seasons of little or no fruit production (Figure 10). Soybeans, or a mixture of soybeans and sudan grass, make good summer cover. Winter cover has been used primarily for prevention of soil erosion and to increase soil organic matter.

For winter cover, oats or winter rye are most commonly used. With fruits in which it is desirable to have little or no spring growth of the cover, oats are usually preferred, while in cases where it is desired to get considerable spring growth for green manuring purposes, rye is used. Some seedings for winter cover have included a winter annual legume (hairy vetch or crimson clover), but this has not been a common practice, although the inclusion of such a legume is recommended and should provide better cover and more organic material for green manuring purposes. From observations during the last three years, vetch seems to be preferable to crimson clover. Although the latter has been used successfully in the area for a number of years, this is far north of its recommended range as a winter annual. Vetch is objected to in grapes, since it is difficult to cut out of the rows when weather conditions have delayed early spring cultivation.

Time of seeding is an important factor in the use of winter cover. In young orchards, where it is especially desirable to prevent late growth of the trees, seedings may be made as early as mid-July. In mature bearing orchards, the cover crop should, in most cases, be sown before the fruit becomes heavy enough to prevent seeding operations in the orchard.



Figure 10. Soybeans and sudan grass in young peach orchard for summer cover and for soil building purposes. (Mich-494)



Some seedings have been made too late in the fall to attain sufficient growth to be of much value for erosion control throughout the following winter. A good cover of woods, or summer grasses, should not be destroyed in order to seed winter cover at a late date. The early seedings of 1938 produced good stands of cover, but were destroyed by rust early in the fall. In 1939, many of the early seedings failed again. Only a few were reseeded and consequently, little protection was provided during the winter. Where winter legumes were included in the seeding, rust damage to the eroded cereal did not leave the soil so completely exposed to erosion.

Biennial cover.

Biennial cover is not commonly used. It includes the use of such crops as sweet clover or hairy vetch, seeded in the spring and remaining through the second year. This type of cover is used in young plantings where cultivation is maintained along the tree row. Cover in the middles protects them from washing and provides for a soil improving program while the orchard becomes established. The recommended practice is to cultivate the rows until the trees come into bearing. Sod buffers should then be established in the rows, the middles being cultivated and seeded to winter cover crops.

The use of sweet clover between tree rows in young plantings has been a common practice on this project, but because of management problems, more favor is now being given to red clover. When sweet clover is used, it should be clipped about May 30 in the second year. Clipping should be sufficiently high so that two or three of the lower branches remain. Clipping too low or too late usually kills the entire stand, but if left unclipped, the plants become rank enough to hinder fruit harvesting operations. Other methods are rolling or disking about the time the sweet clover plants begin blooming. Any of these methods which prevent tall, rank growth are satisfactory and will allow for the production of seed from which a volunteer stand may appear the following year. Frequently, the volunteer stand fails to appear. This is probably due to insufficient moisture for the germination of the hard seed. In instances where mature sweet clover was disked sufficiently to cover the seed before winter, satisfactory stands did volunteer the next spring.

The spring seeding of hairy vetch has not been common, but where it has been tried, cover was furnished somewhat sooner than in the case of sweet clover, although the amount of organic matter provided was not so great.

Red clover will furnish good cover and often persists longer than either vetch or sweet clover. In most of the project area, red clover stands have been obtained rather readily.

Perennial cover.

Perennial cover includes all types of permanent sod, with various modifications of sod cover. The use of sod in orchards does not necessarily mean that the entire orchard is in sod.

Certain problems have arisen in the establishment of continuous cover in orchards and there has been some lack of information as to how far the practice of permanent sod might be carried for erosion control without being detrimental to fruit production. It is believed, now, that with an average amount of rainfall and proper management, continuous sod may be used in apple orchards on medium and heavy soils in this area. On the lighter soils, however, continuous, complete sod may compete too severely with the trees, especially in years of light rainfall.

There is need for more information on the use of sod in peach orchards. Where vegetative cover has been permitted to remain for a number of years, decreased yields have been reported, but with an improved quality (color) of fruit. In some instances, the improvement in quality was said to offset the reduction in yield.

To adapt the use of vegetative growth for soil conservation in such a way as to permit cultivation and yet effect control of erosion, certain modifications of a complete and permanent sod have been introduced. The practices, then, where permanent cover is used, are as follows:

Complete sod. (With or without management practices.)

Sod and mulch. (Sod between rows and mulch under the trees.)

Alternate middles in sod. (Remaining middles cultivated.)

Sod buffer strips in tree rows. (4 to 6 feet wide.)

(In the latter two cases, the sodded areas cross the major slope.)

Where each of these should be used will not be discussed here. It is sufficient to say that for the best erosion control, sod cover should be used in any orchard where soil and climatic conditions will permit it without entering into serious competition with the trees. The most concern is evidenced with respect to the use of a complete sod cover.

There is still a question of what grasses are best adapted for providing sod in orchards. While soil conservation is not the only consideration in answering this question, it is of prime importance and first consideration should be given to those species which are most easily established and survive under orchard conditions. Recommendations concerning species which will furnish the least competition to the trees can be made only after considerable careful research. Observations of seedings on the project, however, may be used as indicative of what grasses may be expected to provide good stands in the orchards of this section.

During the first year of the project, a number of seeding mixtures were used for establishing sod in orchards. These were modified in 1937 and since that time, two mixtures have been used generally. They were designated as Mixture No. 1, seeded at 20 pounds per acre, and consisting of 6 pounds of Canada bluegrass, 2 pounds of Kentucky bluegrass, 4 pounds of sheep fescue and 4 pounds of redtop; and Mixture No. 2, seeded at 15 pounds per acre and composed of 10 pounds of Canada bluegrass, 2 pounds of Kentucky bluegrass, 5 pounds of redtop and 3 pounds of red clover.

No recorded observations were made following the early seedings, but 1938 observations of 1937 seedings of the two mixtures just mentioned, indicated that redtop and orchard grass were furnishing the major portion of the cover at the time observations were made. More extensive observations in 1939 substantiated this indication. The failure of bluegrass was probably due to poor quality of seed and somewhat to untimely seedings. The inclusion of some red clover in seed mixtures is recommended. While fall seedings are considered more likely to be successful than spring seedings, the rush of other farm operations in this section at the time of fall seedings, has caused spring seedings to be more common. Both orchard grass and redtop have succeeded rather well from spring seedings in this area.

Where pure seedings of timothy, orchard grass, sheep fescue, Chewing's fescue, redtop, Canada blue grass and smooth brome grass were made early in September, 1938, by the Michigan State College Extension Horticulturist, all produced good stands and are providing good cover. The two fescues appear to hold promise for erosion control, without making excessive top growth. Which grasses will endure longest and be most satisfactory for orchard use, is yet to be determined.

A low growing grass, which forms a good soil protecting turf, but which makes little summer growth, would be ideal for orchards, but without one having these characteristics, certain management practices should be followed with the species commonly used. These include mowing to prevent excessive top growth and some breaking up of sod-bound areas by disking or other means.

For a time, Poa bulbosa (a bulbous bluegrass) was tried in a few orchards. The habit of this grass to mature early and then remain dormant until fall, gave it some promise as an orchard cover. Fall growth comes from bulbs produced at the base of the plant, as well as bulblets produced in the heads. The growth produced was not sufficient to be of any great value as a soil binder through winter months.

Considering stands obtained, price of seed, habits of growth and ability to control erosion, redtop, timothy and orchard grass might well be used for orchard seedings. Owing to the prevalence of Canada blue grass in the project area, it is likely that if the seeded areas are unmolested, this bluegrass will eventually establish itself. Seeding recommendations must be modified in accordance with conditions existing in any specific orchard.

The value of fertilizer in establishing good cover in orchards cannot be overlooked. Emphasis has been placed on its use with new seedings, to guard against possible failures. In this way, better stands and more vigorous growth have been obtained on areas subject to erosion and consequently, better erosion control has been provided.

The kind and amounts of fertilizer has depended on the soil conditions within the orchard being seeded. In general, the recommendations for various soils and crops made by the Michigan State College have been followed. On areas where soil loss by erosion is evident, the amounts recommended should be increased proportionately with the amount of soil lost.

On eroded slopes, the chances for a successful seeding will be materially increased by the application of a light mulch after seeding. Any strawy material or hay may be used. The mulch helps retain moisture, needed to germinate the seed, near the surface and protects the young seedlings from being washed out before they have established a good root system.

Conclusions.

The value of a good cover crop cannot be overemphasized.

The effectiveness of contouring or terracing is increased materially by the use of a cover crop in winter or in both summer and winter.

Early seeding of cover crop is recommended; mid-July for young orchards, and mature orchards should be seeded when the operation can be made without the interference of fruit laden limbs.

Sweet clover and red clover are recommended with proper management.

Of the seed used in mixtures to establish perennial cover, redtop and orchard grass have succeeded best under adverse conditions.

The recommended seed mixture for perennial cover in orchards should include redtop, orchard grass, Canada blue grass, and red or alsike clover.

When fertilizing orchards, consideration should be given to the food requirements of the cover crop, as well as the trees.

Contour planting of orchards.

The only contour planting in the project area, prior to its establishment, was on the Carl Hauck farm. From his experience, Mr. Hauck was aware that practices ordinarily used on flat land did not fit the hills. About 30 years ago, he decided to set grapes on a steep slope along Blue Creek. The grapes were set on benches, plowed approximately on the contour. The site proved to be somewhat frosty and after the grapes had been in 13 or 14 years, they were removed. Every other bench was removed by plowing, thus giving the remaining benches a wider spacing. These new and larger benches were contour planted to cherries.

Contour planting, with the exception of the case mentioned above, has been regarded as a new thing in this territory and, like most new things, it has been looked upon with considerable skepticism. Scores of questions concerning contour planting have been raised by farmers. Slowly, the answers are being unfolded, although some of the questions will go unanswered until more new contour plantings come into bearing.

Plantings on the contour have been made on a wide range of soil types, slopes and erosion. The soil types range from the lightest, a Plainfield loamy sand, to one of the heaviest on the project area, a Miami silt loam. The slopes range from less than 3 percent to as much as 15 percent and erosion varies from less than 25 percent to 50 percent of the topsoil removed by sheet erosion.

The first contour planting of fruit was in 1936, consisting of a half acre of red raspberries. The contour rows were laid out, using a dumpy level and a leveling rod. This work was done on a fairly regular slope and has proved satisfactory to date (Figure 11).

In the spring of 1937, this practice had begun to be accepted somewhat more favorably, 43.1 acres of fruit trees being planted on the contour, 7 acres of which were terraced.

The first contour planted orchard in 1937 was a 5-acre block of peaches set on level terraces on the Roy Butzbach farm. This planting (Figure 12) proved satisfactory enough that in 1938, with a modification of the type of terrace used (see "Terracing in orchard land"), 2.8 acres were added. Pleased with the effective erosion control he had secured with this practice, Mr. Butzbach contour planted another 15 acres on terraces in the spring of 1939. This brought his total contour planting to 22.8 acres. For a complete lay-out of this plantation, see Figure 13.



Figure 11. First contour planting. The first contour planting of fruit on the Benton Harbor project, 0.5 acre of red raspberries near Hinchman, Michigan. (Mich-102)





Figure 12. First contoured orchard, 5-acre block of contour planted peaches set in the spring of 1937 on the Roy Butzbach farm, Bainbridge Township, Berrien County. Photographed in the summer of 1938. (Mich-254-A)



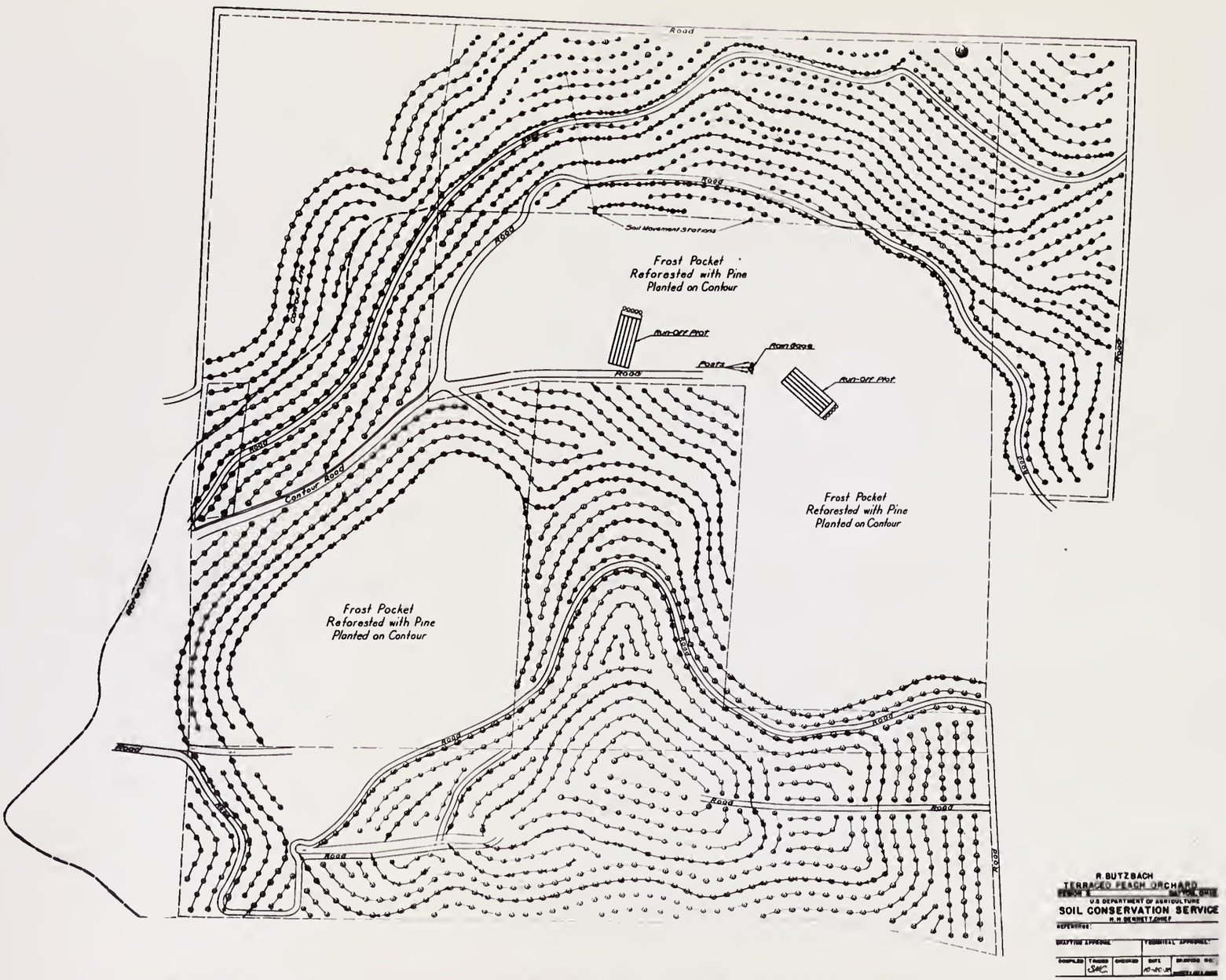


Figure 13. Complete lay-out for 22.8-acre terraced orchard on the Roy Butzbach farm, Bainbridge Township, Berrien County, Michigan. Each heavy line is a terrace and each small dot a tree. Scale 1" = 317'.

This orchard was set on a light soil (Coloma loamy sand) with slopes ranging from 5 to 13 percent and on the average, 50 percent of the original topsoil removed by sheet erosion caused by both water and wind. The original planting bore a partial crop in 1940. To date, soil erosion has been controlled. On June 21, 1939, during a rainfall of 5.1 inches intensity per hour, only one level terrace cut through.

In laying out unterraced contour orchards in 1937, a small hand level (Abney) was used to lay out contour lines. This gave lines which were only approximately on the contour. If a grower disliked some of the kinks, or if he insisted the rows were too crooked, they were modified, to satisfy him. This, of course, threw the rows off contour, as much as 3 percent in some cases. Observations made during the summer of 1937 gave some indication, especially on the heavier soils, that these lines should be kept on a true contour, if possible.

In 1938, there was increased interest for contour work during the spring planting season. By the close of the season, 96 acres were contour planted to orchards and of this amount, 55.8 acres were terraced. The use of the hand level for orchard lay-out work was discontinued to some degree. However, a few orchards were still planted a little off contour, because the growers still objected to rows that were too crooked.

Continued observation in these contour planted orchards, climaxed by a rain of 1.93 inches on the night of June 30, 1938, showed beyond any reasonable doubt that contour planted orchards should be set so that each through row would handle the run-off from the area above. This meant somewhat of a change of ideas. Under this system, it would be impossible to sacrifice adherence to the contour or grade line (see "Orchards set to terrace grades") in order to straighten the rows. Unless it is possible to fit the rows to the topography of the land, contour planting should not be attempted, except perhaps, on the very sandy soils where water will be taken up rapidly. By setting each through tree row to a terrace grade, the excess water will be directed to a common waterway which must be provided.

By the spring of 1939, a large percentage of the contour planting, planned in original agreements, had been laid out. However, during this year, 79 acres of orchards were laid out on the contour, of which 41.4 acres were terraced. Seventy-five percent of the total 1939 planting was done by amendment; that is, the growers, although they had accomplished all they had originally agreed to, had seen enough erosion control accomplished by contour planting to request an increase in this type of work. In the fall of 1939, an additional 27.5 acres were laid out on the contour for planting in the spring of 1940. Additional lay-out and planting done in the spring and fall of 1940 brought the total contour planting (January 1, 1941) to 281.0 acres, 104.2 acres of which were also terraced.

All of the orchards laid out in 1939 and 1940, with the exception of two which were on porous, sandy soil, were given a terrace grade for each through tree row. The growers were gradually becoming accustomed to seeing crooked rows and knowing they are for erosion control, are much more willing to have short turns in the tree rows.

As the growers become accustomed to contour planting, they have more confidence in this method of erosion control. One grower near Hinchman said: "I would like to put that piece of ground to peaches, and I want it laid out so it won't wash." Another grower, Lewis Umphrey, of Bainbridge, whose agreement was amended to accomodate three contour planted orchards, said: "After five years of working on this program, I can begin to see what I should have been doing on my farm 15 years ago."

The lay-out method has been varied according to the slope and the type of fruit (see "Terrace lay-out"). On slopes up to 10 percent, peaches have been spaced 22 or 23 feet between rows. On slopes over 10 percent, the spacing has been 24 to 26 feet between rows. On extreme slopes, spacing has been as much as 30 feet for short distances. These spacings have been used with the idea of preventing interference from side slippage of orchard equipment. They have been varied as much as 10 percent to take care of special conditions.

One of the standard control measures for brown rot control in peaches is to spray or dust just before picking. With old spacing of 18 by 18 feet, or 20 by 20 feet, it was rather difficult to get through an orchard loaded with mature fruit. Widening the spacing one way in the orchard will help alleviate this condition and perhaps encourage better brown rot control.

Spacing in the row generally varies with the spacing between the rows. This has been done to keep the recommended number of trees per acre wherever possible. The minimum spacing in the rows has been 16 feet for peaches and 30 feet for apples.

In the past, growers have been prone to place too many trees per acre on the sandier soils which are more drouthy and least able to support a large number of trees. This has been done, as pointed out by many growers, because the trees are usually smaller and there is room for more. By using the same spacing on the sands as on the heavier soils, this condition has been partly corrected with new plantings.

Spur or short rows have caused some concern to growers who felt that these would make it necessary to turn in the middle of the orchard. There also has been some tendency for water to concentrate on the upper side of the shorter rows and cause some cutting at low points in the rows. This has occured particularly during heavy rains, especially during a 2.5-inch rain on June 21, 1939. From observations of orchards in sod and mulch, it is believed spur rows might well be managed with the sod and mulch system, thus both eliminating the necessity for the grower to turn in the middle of his orchard and reducing the tendency toward cutting at low points in the row.

Conclusions.

To control erosion with the least amount of sod, the most benefit can be obtained in an orchard which is set on the contour.

In all cases, in setting an orchard on the contour, absolute contours should be adhered to, or the rows set on terrace grades and waterways provided.

Contour planting can be accomplished without any appreciable decrease in the number of trees per acre.

Some land has topography too irregular and slopes too sharp for contour planting to be practical.

Some of the questions on contour planting will not be answered until some of the orchards have passed through their life cycle.

Due to the long life of the orchard, lay-out work should be done by someone who has had experience in this type of work.

Ridges will gradually be built along the tree row.

Contour planting is one of the most efficient methods of erosion control and provides the foundation for the use of other erosion control practices.

There is still need for further study of certain problems arising with contour planting of orchards.

More observations should be made on the benching effect along the tree rows and the handling of spur rows.

As the trees become mature, observations should be made to determine if the tree spacings can be improved.

Observations should be made on the use of sod and mulch on spur rows.

More observations should be made on the orchards laid out to terrace grade, but left unterraced.

Terracing in orchard land.

History.

Orchard terracing was practically unknown in the project area prior to 1937. The only terracing in the area prior to that time, was a benched terraced cherry orchard on the Carl Hauck farm (see "Contour planting of orchards"). Although the acreage terraced on this farm was small, the principle of working on the approximate contour and building a bench terrace had been tried and proved there for 14 years before the Soil Conservation Service began terracing in Michigan. Mr. Hauck allowed sod to form on the bench risers. The cherry trees were planted along the terrace near the top of these risers. The flat areas of the benches were inter-cropped to truck or asparagus.

More detailed comment upon the early terracing by the Service on this project appears in the appendix.

Results of observations on orchard terraces are given in a report (1940) on "Orchard Terracing", as a special study from this project. This report may be referred to for more detailed information regarding the subject.

Level terraces.

Whether with closed ends or open ends, level terraces should be used only on deep sandy soils, where they will have a complete year around vegetative cover. Results have shown that where level open-end terraces were used and no vegetation existed in the terraced area, overtopping occurred. Overtopping was caused by the sealing of the terrace channels by fine silt, washed in from the terrace interval. The maximum length of these terraces was 1800 feet. Short, level terraces with open ends have been successfully used in sandy orchards where a double cover crop system was used. If design of terraces must be such that they will withstand the worst possible conditions, level terraces must be used only with extreme caution, even on the most absorptive sandy soils. The level closed-end terraces built in the project area have worked satisfactorily because the vegetation on the terraced field has not permitted the sealing of the terrace channels (Figure 14). Slopes on which level terraces have been built range from 5 to 10 percent. Except for the first terrace jobs, few level terraces were built, because it was felt that enough of both closed-end and open-end level terraces had been constructed to provide an adequate demonstration.



Figure 14. First orchard terraces built in the project area on the Roy Butzbach farm in Bainbridge Township. These are level, closed-end terraces of the absorptive type. Note the holes being dug on the terrace ridges for peach trees. Since this orchard was terraced, Mr. Butzbach has added approximately 17 acres of terraced peach orchards adjoining this field. (Mich-254)



Terrace lay-out.

The first orchard terraces on the project were laid out according to standard spacing, as given for the North Central States (12). The top terraces were laid out and designed as diversion channels (See "Diversion channels" under Meadows, Pastures and Cropland"). At first, little thought was given to the correlation of terrace spacing with tree row spacing. In the second year of orchard terracing work, an attempt was made to space terraces according to accepted tree row spacings. This simplified orchard lay-out work considerably and cut the number of short or spur rows to a minimum.

In lay-out work for orchard terracing, slopes are frequently encountered which would be considered too steep to terrace as general cropland. (This condition arises from the fact that in certain cases, the more level land is likely to have poor air drainage and the resulting frost damage would cause considerable loss to the grower). In such instances, it has been found best to lay out a terrace for every through tree row; that is, each row which crosses the steepest slope of the prospective orchard. Lay-out, in this case, usually starts on the steepest slope and the terrace line is run in each direction.

Since terraces on the steeper slopes, especially in sandier soils, will probably result in benches eventually, it is advisable to have a terrace for each tree row. On the more gentle slopes, it has been found sufficient to lay out a terrace for every other through tree row. Terraces on the gentle slopes are more easily maintained and the land may eventually be used for something other than tree fruits.

Terrace spacing on the steeper slopes is held at 22 to 26 feet for peaches and 40 to 50 feet for apples. On the more gentle slopes, spacing of 44 to 52 feet is used for peaches and 80 to 100 feet for apples. The size of the terrace and cross-section should be varied to conform to the spacing.

When trees are set on the square, the accepted spacing for peaches is 18 or 20 feet and for apples, 35 to 40 feet. To allow for some slippage of tillage implements, the spacing between rows should be increased 2 to 5 feet in terraced orchards. The trees may be spaced closer in the row (minimum 16 feet for peaches and 30 feet for apples) so that approximately the same number of trees per acre may be planted under the terrace system with rows on contour, as under the square system.

In old, established orchards, where it is exceedingly difficult to lay out, space and construct terraces of proper cross-section, it has been found best to decrease the standard spacing, as given for cropland for North Central States (12) by 20 to 30 percent.

Location of trees.

In all cases, the trees were planted on top of the terrace ridges. This location was considered best for ease in cultivation and terrace maintenance. Cultivation tends to create ridges in the tree rows and so reduces the amount of cultivation required.

Some consideration was given to locating the trees at the lower edge of the terrace ridges. Maintenance, in this case, would be chiefly from the upper side of the terrace ridge and would cause a gradual shift of the ridge until eventually, it will be in the tree row.

No orchard terrace system has been used on this project, where the trees were omitted from the terrace, as has been done elsewhere, for ease in terrace maintenance. It is doubtful if any grower in this locality would be willing to sacrifice the amount of land that would be required to do this.

Terrace sections.

The first terraces were built with the cross-section similar to the broad base absorptive type. However, construction difficulties experienced on the sandier soil caused most of the early terraces to be narrow base absorptive type terraces. That is, they were constructed from both sides, when possible, and had a rather narrow high ridge. In cases where the terrace spacing was decreased by correlating terrace spacing to tree row spacing, the size of the terrace was reduced. It was felt that a narrow base terrace, with a settled height of 15 inches, would be of sufficient size for the relatively close spacing used and also, that the smaller terrace could be easily maintained. Approximately 30 percent of all orchard terraces built in the project area were of this narrow base absorptive type.

With improvements in terracing equipment, this type of terrace was easily and economically built, the average cost being $8 per acre, or $65 per mile. This cost is considered reasonable, because the average length of an orchard terrace in the Benton Harbor area is approximately 500 feet. The cost per acre is higher, and the cost per mile lower, than would be expected from a standard spacing, since closer spacing gives more miles of small terraces per acre.

The terrace ridges, although lowered by the decrease in terrace spacing, tended to have sharp crests when constructed from both sides. The sharpness of this ridge was further increased when a disk was used to cultivate the terraces. In order to aleviate the disadvantage of the sharp ridges, the absorptive type terrace was replaced by the channel or drainage type terrace early in the summer of 1938.

By building the drainage type terrace from only one side, construction difficulties were minimized, because it was unnecessary to move dirt laterally for any great distance. The smaller accumulation of fill dirt in the ridge, and the blending of this ridge into the land below the terrace, met with the approval of the cooperator and the horticulturist alike.

Where terraces were built on the more drouthy soils, a friable subsoil usually allowed as much percolation with the drainage type terrace as with the absorptive type. The cost of construction of this type terrace was lower than the absorptive type, averaging $5.50 per acre and $45 per mile.

Terrace grades.

The building of level terraces for maximum percolation was prevalent only during the first year of orchard terracing. Thereafter, no level terraces of a greater length than 300 feet were built. The most satisfactory grades to use should be classified according to the soil type. For the lighter sands, a level grade used on the upper 200 or 300 feet, with a 0.2 foot fall per 100 feet for the remainder of the terrace, has proved satisfactory for terraces up to 1,200 feet in length. For a loamy sand, with a retentive subsoil, a uniform grade of 0.2 percent is best for terraces up to 1,200 feet in length. For silt loam or clay loam soils and soils with impervious subsoils, a variable grade terrace having a minimum grade of 0.2 percent and a maximum grade of 0.4 percent has proved satisfactory, with one exception. Where seep areas or wet spots occur, it has been found best to increase the grade to 0.5 percent. This is necessary to provide adequate drainage.

Construction and equipment.

The terracing equipment used most on the Benton Harbor Project consisted of a 20 horsepower crawler type tractor and a No. 1 Caterpillar terracer. Terrace construction on the more sandy soils of the project has always been difficult. In the early attempts to build the Mangum type terrace, difficulty was encountered in obtaining a section of sufficient width. This was due to the inability of the terracing machine to move the sand laterally. The sand, unlike the silt and loam soils, will not roll ahead of the terracer blade if it is fairly dry, but will pile up and push in front of the blade. If the blade is set on a more acute angle, the terracing machine skids to the side without moving the sand.

The sandier soils allow steel terracer wheels to sink into the soft subsoil occasionally, causing the blade to dig a groove in the terrace channel and as terrace construction progresses, these grooves become a series of waves. The first of these difficulties was remedied by changing the type of terrace section; that is, from the absorptive type to the drainage type. In the construction of the latter type of terrace, the amounts of sand moved laterally are smaller and at no time during construction is there need for moving large quantities of fill dirt. For further details regarding terracing equipment and improvement made in terracing equipment, see "Terracing equipment" under "Notes on orchard terracing" in the appendix.

Terracing in established orchards.

Seven terrace systems were build in established orchards in the project area. Since most cooperators object to removing more than 2 or 3 percent of the trees in an orchard, the use of large equipment is limited to orchards which have a wide tree spacing. In those with relatively close tree spacing, small terracing equipment has been used successfully. In close spaced orchards, it is also desirable to use a terrace with a small cross-sectional area and a correspondingly closer terrace spacing, because the available area to be disturbed is limited.

The lay-out of these terraces is a difficult operation, being done best in late fall or early spring. The grades used in lay-out vary, because it is sometimes necessary to vary the grade in order to miss a tree. If the tree is not cleared properly by the terrace, the grade may be increased or decreased, or a cut or fill may be made. Wherever the grade increase is excessive, the channel of the terrace should be sodded. In construction, the cuts and fills are first made with a slip scraper. If the soil is heavy, the terrace lines should be plowed before a Corsicana or similar light terracer is used. The channel type terrace built from one side is best suited for established orchards. The terraces, as well as an area at least 30 feet wide above the terrace, should be maintained in continuous sod. (See "Sod in orchards"). These small terraces are also best suited to the sod type of orchard management. Where the terraces have been maintained in sod, no appreciable difficulty was encountered when they were crossed with rubber-tired spraying equipment.

The cost of terracing in established orchards varies considerably, depending upon the tree spacing, the soil, slope and the amount of erosion. Costs range from $5.50 to $26 per acre.

A series of bench terraces were built in one established apple orchard. These benches were built with the project terracing equipment and finished by a team and slip scraper. The maximum slope between the terraces was 20 percent. The benches were built sufficiently wide to accommodate spraying equipment. They were seeded and mulched upon completion and have remained under sod cover since. The benches have worked satisfactorily and the co-operator is well satisfied. The cost per acre for doing this type of work was $114. It is believed that immediate control of the steep terrace risers and back slopes by vegetation is essential for successful bench terracing.

Terrace maintenance.

Terrace maintenance under orchard conditions presents a number of special problems. (See "Terrace maintenance" letter to cooperators under "Notes on orchard terracing"). Orchard terraces are seldom plowed because of the difficulty encountered in plowing close to the trees. Where they are plowed during the first 3 or 4 years, the usual method of plowing back furrows to the terrace ridges and to the in-between trees, with dead furrows in the terrace channels, may be followed (Figure 15). However, since the lands are small and because each tree row will include two lands if dead furrows are plowed in the terrace channel, it is recommended that the small sections, left unplowed after all through rounds have been made, be disked. These areas will not be large and the amount of turning necessary to plow them out might be excessive.

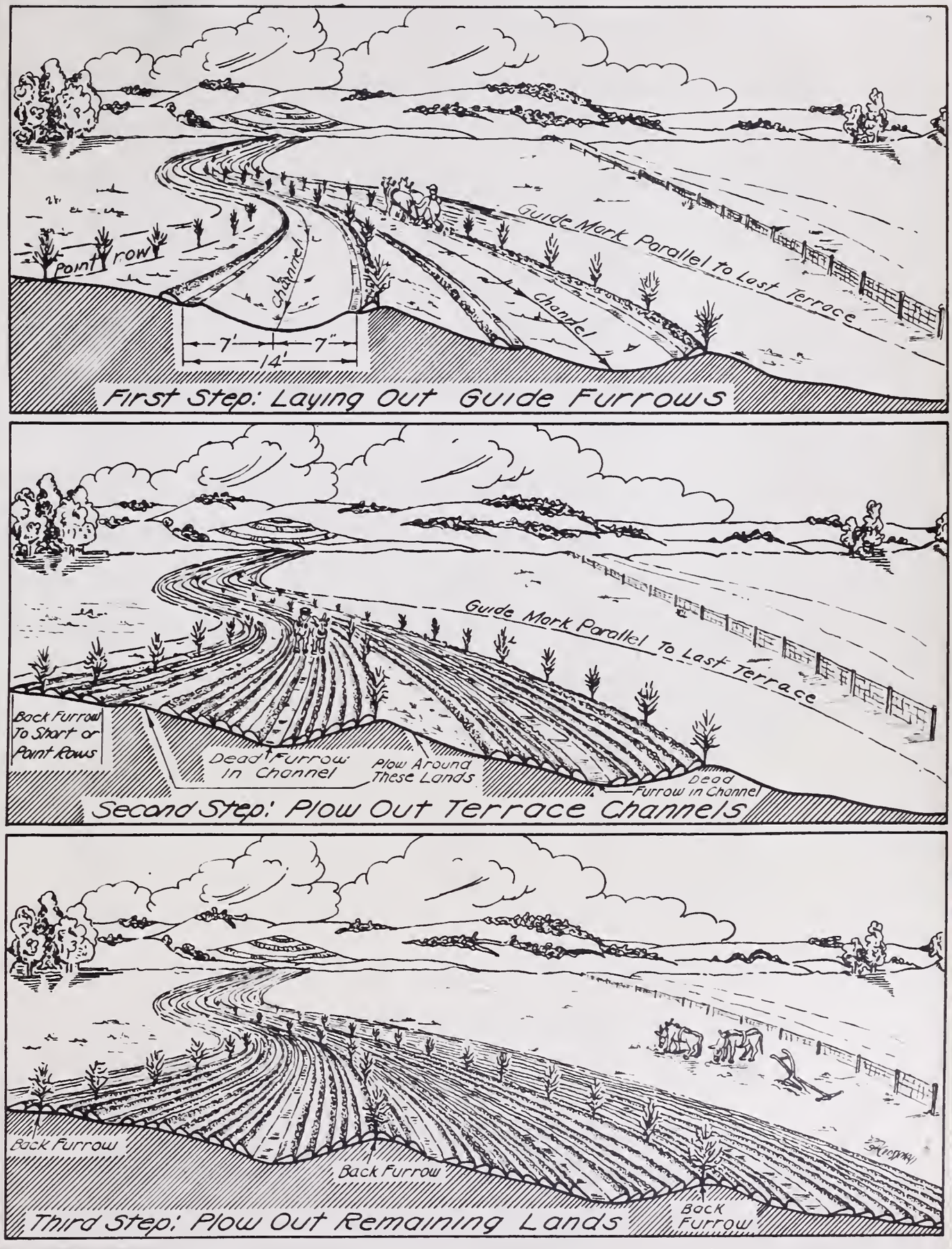


Figure 15. Steps in terrace maintenance

Soil deposits caused by breaking through of in-between tree rows during the first few years (see "contour planting of orchards") are best removed by using a slip scraper and a V-drag.

Of the various methods tried on terrace maintenance, disking seems to be the best. If deposited soil is evenly distributed in the terrace channel, most of it may be removed by proper disking. A single disk is best suited for this purpose, although excellent results have been obtained by using an offset tandem disk. For best results, a single disk 8 or 10 feet long should be set to work the ground away from its center. The front half of most tandem disks may be similarly set. The disk should be operated parallel to the terrace ridge, so that the soil is worked toward the trees, or to the top of the terrace ridge, by one section of the disk, while the other section is permitted to run in the terrace channel. On a return trip, one section of the disk is again run in the terrace channel , while the other section moves the dirt up the terrace back slope, away from the terrace channel. Two or more rounds may be necessary, depending upon the condition of the channel.

With an offset tandem disk, the back section should be set to work the soil toward the trees. It may be necessary to reverse the "Y" hitch on most offset disks to accomplish this. In using this type of disk, the same steps should be followed as in maintaining terraces by plowing. The side toward which the back section moves the dirt should be regarded as the mold board side of a plow.

Farming orchard terraces.

The most common tool used for cultivation in orchards on the project area is the disk. The disk, unless exceptionally rigid in the center, works satisfactorily on orchard terraces and if used properly, it can be effectively used for terrace maintenance. The amount of terrace maintenance needed depends upon the management of the orchard. Contour cultivation, cover crops in both summer and winter and modified sod, if moisture conditions permit, all tend to reduce the amount of terrace maintenance. Terracing in itself is not a guarantee of permanent erosion control. It should be considered as a base or foundation upon which other practices may function to maintain and improve soil fertility.

The use of rubber tires, on both tractors and spray rigs, is increasing in the project area. It is believed that no particular difficulty will be experienced in working or spraying terraced orchards when rubber-tired equipment is used on the sandier soils and crawler type tractors and rubber-tired spray rigs are used on the heavier soils. (See "Conclusions" under "Contour planting of orchards").

Orchards set to terrace grades.

During the year 1939, the number of orchards set to terrace grades, but left unterraced, except for back furrowing to the rows, was greater than was the number terraced. There are a number of reasons for this. First, many cooperators may not decide to set their orchards until just before planting time and consequently, terracing equipment is not available. Second, in many small orchards, where every through tree row is set to a terrace grade, it is believed to be more practical to let the grower build his terrace by plowing and disking. Third, terraces may be built later, when more time is available or if an emergency arises.

In using this method, the orchard is laid out as though it were to be terraced, the key or through rows being the terraces. The lines are then plowed in, four to six furrows being thrown together as a back furrow, to represent the key or terrace row which was set to a terrace grade. Fewer furrows are thrown together to make the in-between or short rows. The terrace cross-sectional area will be undersized for a number of years and overtopping and cutting through may occur for some time, especially where the site has been subject to gully erosion previously. However, when the life of the orchard is considered, there can be no doubt as to the advisability of using this method as an emergency measure, regardless of the size of the orchard, because eventually, a satisfactory terrace section can be built. Owing to the fact that the terrace cross-section will be undersized for a time, it is believed advisable to increase the terrace grade to a uniform grade of 0.4 percent, so as to minimize overtopping as soon as possible.

Conclusions.

On sandy soils, where slopes are over 3 percent and where the length of terrace is over 500 feet, level terraces should not be used except in special cases.

On slopes over 8 percent, a terrace should be built for every through peach tree row and on slopes over 5 percent, a terrace should be built for every through apple tree row.

The drainage or channel type terrace is best suited for orchard terracing.

Recommended grades for orchard terraces on sandier soils and soils having a friable subsoil are: level for the upper 300 feet and 0.2 percent for the remainder of the terrace up to 1,200 feet in length. On medium soils, a uniform grade of 0.2 percent is recommended for terraces up to 1,200 feet in length. On the heavy soils, or soils having impervious subsoils, a variable graded terrace, having 0.2 percent as the minimum grade and 0.4 percent as the maximum grade, is recommended, except for seep areas and wet spots, where the grades should be increased to 0.5 percent.

In established orchards, small drainage type terraces, with a close spacing, should be used. The terrace should be maintained in continuous sod.

Whenever terracing equipment is not available, or time does not permit terracing, the key or through tree rows should be laid to a terrace grade. A minimum grade of 0.4 percent is recommended for these rows.

The amount of terrace maintenance needed depends directly upon the management practices.

Terrace outlets.

Nearly all terrace outlets used for orchard land were vegetatively controlled. The means by which vegetation was established are described under "Vegetative control" under "Gully control in orchards."

Natural drainageways were used whenever possible, as terrace outlets. However, the natural drainageways were frequently located in established orchards. Under these circumstances, it was necessary to construct an artificial terrace outlet to be used temporarily until the established orchard was removed and the terrace could be extended to the natural outlet. The location of temporary outlets was usually along field boundaries.

For further information on the design of terrace outlets, see "Terrace outlets" under "Notes on orchard terracing" in the appendix. (See, also "Notes on gully control").

Most of the outlets were designed for a rather small drainage area, the average being only 5 acres. For this reason, special measures were not used to divert the run-off water from a terrace outlet while seedings were being established. On the sandier soils, a few terraces were blocked temporarily and this method has worked satisfactorily. Wherever possible, outlets were established prior to terracing and in some cases, gullies, which were previously revegetated as part of the gully control program, were used. In general, seedings were mulched and the mulching material was held in place by using old cattle fencing and wooden stakes (See Figure 16 "Vegetative control" under "Gully control in orchards"). The average cost of this control was approximately 10 cents per square yard. This method of control was considered both satisfactory and economical.



Figure 16. Mulch and old cattle fencing used in establishing vegetation in drainageways. Although the picture above is of a highway road channel which was stabilized by using fencing material, the same method has proved successful in many drainageways on the project area.

The fencing material was fastened to the ground by using wooden stakes and small staples. (Mich-290)



Outlets were constructed by using a No. 1 Caterpillar terracer. Dirt was drifted from the center of the channel toward the sides and spread over the field. The side slopes were made as flat as possible and the channel bottom was constructed flat and level. Before seeding, the outlet was disked if possible. A single disk set to work the dirt away from the center was usually used. If disked in this way, the finished terrace outlet cross-section had a slightly rounded bottom.

On the heavier soils, where the subsoils were unproductive, topsoil was drifted back into the channel and mixed with the subsoil by disking before seedings were made. On the sandier soils, no attempt was made to drift a light covering of topsoil back into the channel, because satisfactory stands of vegetation were established on the sandier subsoils by using mulch and fertilizer.

The maintenance of terrace outlets for orchard land presents special problems, many of which are yet unsolved. Outlets are usually rather small, because of the relatively small drainage areas and the vegetation must, therefore, be clipped by hand. Consequently, clipping is often neglected. Then too, many cooperators do not have mowing equipment.

Because of the excessive siltation caused by the sandy soils of the area, outlets cannot be built wider than good design dictates. The amount of sand carried into an outlet depends upon the orchard management and cultivation practices.

At the outset, it was believed best to locate the terrace outlet at the edge of the field, so that it would not be necessary to cross it with tillage implements. Since that time, however, some difficulty has been encountered in turning at the outlet end of the terrace because of a lack of sufficient space between rows, especially in peach orchards. Turns may be made between tree rows with a small tractor and a light disk, if they are made in a down-hill direction. The disk marks left in an up and down hill direction near an outlet cause some erosion and in turning, the disk tends to cause a dam to be built at the end of the terrace. This condition is still more serious where larger and heavier equipment is used and it is necessary to cross a row or terrace at the outlet end to effect a turn. Because a slight reduction in velocity will cause sand to drop from suspension, the slowing of the water from the terrace, at the point of entry into the outlet, results in almost the entire amount of suspended sandy material being dropped in this opening. This effect, combined with the damming caused by turning, will cause overtopping of the terraces if maintenance work at the outlet end is not performed at regular intervals.

It is believed that less maintenance would be required if outlets were located so that they may be crossed, provided that improved types of disks or harrows are used which may be tripped or lifted in and out of the ground automatically (the Case power control disk and the Oliver roll-over spring tooth harrow). A number of cooperators have successfully used an automatic trip disk in crossing outlets, without seriously harming the vegetation.

Conclusions.

When possible, outlets should be established prior to a terracing program.

Natural drainageways should be used whenever possible and artificially constructed outlets should be regarded only as temporary measures.

Mowing of vegetation, in some cases, must be performed by hand labor. Cooperators should be taught the proper methods of maintenance.

A minimum amount of turning with tillage implements should be made at the outlet end of terraces. The use of equipment which can be tripped in and out of the ground automatically should be encouraged.

Diversion channels.

Diversion channels have been used successfully as an aid in establishing cover on badly eroded areas, as the top terrace in a system and as a means of diverting storm water from gully heads which threaten valuable orchard land. In locating a diversion channel, the critical point on the steepest slope is chosen as a starting position. The critical point is the place where serious sheet erosion first occurs, as at the heads of "shoestring" gullies, on the steepest slope in the orchard. A suitable outlet may be a gully or natural ravine in the orchard, which can be easily revegetated.

The lay-out and construction of diversion channels in orchard land is the same as given for terracing in established orchards. Diversion channels have been designed for uniform velocities, with a constant cross-sectional area, by varying the grade. Watershed areas were broken in 50-foot intervals along the proposed channel and Manning's formula and Ramser's (8) run-off curves, for a 10-year frequency, were used for design purposes.

Diversion channels, as used in orchard land, frequently cannot be laid out to grades which would maintain a uniform velocity in the channels. In order to maintain a uniform cross-section when a valuable tree cannot be given sufficient clearance, the channel grade has been increased. This means that short stretches of a channel may have excessive grades. In these cases, the methods used in establishing vegetation in the diversion channel are varied with the expected velocity (Figure 17.) That is, for velocities of 2 to 3 feet per second, the channel is seeded. For velocities from 3 to 5 feet per second, seeding is protected by mulching and the mulch is fastened down by using fencing material. For velocities over 5 feet per second, the channel is sodded completely and the sod is fastened down by using old fencing.



Figure 17. Diversion channel built in established orchard to aid in control of erosion on steep slope below. Sod strips across the channel were used to aid vegetation in becoming established. The sod strip on the back slope was used to keep sand from washing into the channel. This method has worked satisfactorily on the light sandy soils. (Mich-86)



Diversion channels are best adapted to orchards which will be managed under a sod and mulch, or a modified sod system. Observations indicate that uniform velocities of 5 feet per second may be safely used for design purposes on the sandier soils and velocities of 3 feet per second on the silt loams. These velocities are about the maximum under which seedings may be established without using excessive protective measures on these soil types and they are about the minimum velocities required to make the channel self-maintaining.

When diversion channels are installed in advance to other control measures on watersheds above, serious silting or sanding occurs in the channels. This is especially true on the lighter soils and during the winter months. Records from soil loss demonstration plots, taken after a rain on partially frozen bare Coloma loamy sand, show a soil loss as great as the run-off pound for pound. A diversion channel cannot be expected to be self-maintaining under such conditions.

In one case, where it was especially desirable that the diversion channel be as nearly self-maintaining as possible under adverse conditions, the design allowed for a velocity of 6 feet per second. The entire channel was seeded under mulch, which was fastened down by using old cattle fencing. It has successfully carried large quantities of both water and soil without being seriously silted in and a fair stand of vegetation has become established in the channel.

Diversion channels for diverting water from gully heads to vegetatively protected outlets or structures have been used primarily in orchards where sod, sod and mulch, or modified sod management was being practiced. It is recommended that this type of diversion channel, which is frequently used toward the foot of a slope, be used only where the watershed above is completely controlled by vegetation.

Maintenance work was necessary on some of the diversion channels on the sandier soils. This has been accomplished economically by plowing and by using a V-drag. Often, native vegetation will come back and reseeding is unnecessary. Siltation will occur less rapidly if the vegetation is clipped regularly and all debris removed from the channel.

Conclusions.

Diversion channels may be best used as aids in establishing vegetation on eroded slopes in orchard land.

If desirable grades cannot be obtained, the grade should be increased and vegetative control established.

Velocities of 5 feet per second are recommended for sandy soils and 3 feet per second for silt loam soil.

Diversion channels are best adapted to orchards which are managed under a sod, sod and mulch, or a modified sod system.

Maintenance work may be accomplished by using a V-drag and plow. The vegetation on a diversion channel should be clipped and the channel kept free of debris.

Gully control in orchards.

General.

The methods used in the establishment of vegetation in gullies are similar to those used in terrace outlets. The design methods used in connection with both vegetation and structural gully control--that is, the design for size of channel for vegetative drainageways, weir notches, size structures, etc.--were the same as given for terrace outlets. For further information regarding channel sizes and structures, see "Notes on terrace outlets, gully control and design of dams" in the appendix.

Vegetative control.

Shaping a gully into a properly designed drainageway cannot be overemphasized, for if the drainageway is improperly designed, severe sanding will soon reduce the capacity, especially on sandier soils where the watershed is not 100 percent controlled. The gully control part of the erosion control program for orchard land of a sandy nature may be considered only as good as the watershed control. In no case should vegetative gully control work precede watershed control. It should be put into effect simultaneously or after control measures are put into effect on the watershed.

At the outset, much of the bank sloping and shaping of gullies was done by hand, because of the large amount of WPA labor available. Later, this work was done by plowing and disking, or by using terracing equipment, depending upon the size of the gully. Design specifications called for a level, flat bottom channel, with three to one as the maximum ratio for side slopes and 18 inches as the minimum depth of channel.

During the first 1.5 years, the brush and litter method was used almost exclusively for getting vegetation established in drainageways. This method consisted of first seeding and fertilizing the disturbed area of the reshaped gully. A light straw mulch was placed over the seeding, just thick enough to shade the ground, or so that the ground was still visible through the mulching material. Weedy hay, clover hullings and shredded corn stover were also used as mulch.

The straw or other material was held in place by placing light fruit tree prunings (maximum diameter 3/4 inch) over the straw. The butts of this brush were turned upstream and the brush was placed just thick enough that the twigs on each branch over-lapped sufficiently to hold the mulch in place. Poles (maximum diameter 1.5 inches) were laid across the gully at varying intervals from 3 to 5 feet, depending on the length of the brush used. These poles were staked to the ground by using forked stakes 18 to 24 inches long. The straw, brush, poles and stakes should be carried well up the channel sides (Figure 18).



Figure 18. Early brush and litter work in which forked stakes were used to hold down poles and brush. Note the severe silting occurring in this channel. A good stand of vegetation was established, but the capacity of the channel was reduced because of siltation. (Mich-79)

When used in watersheds where some control measures had been put into effect, this type of control worked fairly well, but because of the high coefficient of roughness caused by the stakes, poles and brush, many jobs were severely sanded over and the vegetation smothered, especially where the watershed was uncontrolled, or only partially controlled. The forked stakes were objectionable because they extended 6 to 8 inches above the surface of the channel where they interfered with the operation of orchard equipment and collected considerable debris. Despite these shortcomings, maintenance was needed on only a small percentage of the total number of jobs. The total cost of this type of control averaged 14 cents per square yard.

This method of control was improved later by wiring the poles and stakes together with baling wire. This eliminated the forked stakes and reduced the cost about 1 cent per square yard.

In subsequent work, little brush was used. Wire fencing material, either old cattle fencing or poultry netting, was used almost exclusively to hold down mulching material. If the fencing was of a mesh greater than 6 inches, it was laid double. Wooden stakes, having square tops, were driven at least 18 inches into the soil, so that the top of the stake was flush with the surface of the ground. One stake was used for each square yard of fencing. A poultry netting staple was used to fasten the fencing material to the top of the stake, as shown in Figure 16. An abundance of used cattle fencing was available, due to the general trend of the area from dairying to fruit. The cost of fitting old fencing for use in gully control work has been estimated at 6 cents per rod. The average total cost per square yard for this type of control was 12 cents.

Better results were obtained with this wire and mulch system than with the brush and litter type of control. Vegetation was established quicker because there was little shading. The coefficient of roughness was not as great and less siltation occurred. Little difficulty has been encountered in removing the fencing material after a good stand of vegetation has been established. The small netting staple can be pulled out of the wooden stakes easily. The waterway can then be clipped and proper maintenance effected.

A considerable quantity of new poultry netting was used for holding down the mulch. This material is economical if purchased in 6-foot widths, the cost being approximately 4 cents per square yard. It has been as satisfactory as cattle fencing for establishing vegetative control. Less labor is required in laying the netting and the average total cost per square yard is about 10 cents. However, it is difficult to remove poultry netting after a seeding has been established. Although a 2-inch mesh netting was used, it became so firmly matted in the grass that it could not be removed without destroying a considerable portion of the vegetation.

Cotton fabric and Linennet have been used on the project for establishing vegetative control in waterways. The costs of these materials are about the same as those for poultry netting. They are not as durable as netting and in a few cases, they have failed by rotting before a substantial seeding was established. Vegetation was slower in becoming established, since the combined shading by the fabric and orchard trees was excessive.

Seed mixtures and rates of seeding have varied from year to year. At first, no marl was applied and seeding rates were 16 to 20 pounds per acre, with oats or rye seeded as companion crops, at a half bushel per acre.

In 1937, the following seed mixture was used in gullies: 8 pounds of Canada bluegrass, 2 pounds of Kentucky bluegrass, 3 pounds of orchard grass, 3 pounds of meadow fescue, 3 pounds of smooth brome, 4 pounds of redtop and 3 pounds of sweet clover.

This mixture was seeded at the rate of 26 pounds per acre, with companion crops seeded as follows: in the spring, 1 bushel of oats and 5 pounds of vetch per acre; in the summer, 15 pounds of sudan grass and 5 pounds of vetch per acre. The areas seeded were fertilized with 10-6-4 fertilizer, at the rate of 300 pounds per acre and a few of the waterways were marled at the rate of 4 yards per acre.

In 1938, the rate of grass seeding was doubled and marl was used for most of the seedings. The companion crops, as well as the rates at which they were seeded, remained the same as for the previous year.

In 1939, the seed mixture used consisted of: 4 pounds of Canada bluegrass, 4 pounds of Kentucky bluegrass, 2 pounds of alsike clover, 4 pounds of orchard grass, 4 pounds of smooth brome, 6 pounds of redtop, 4 pounds of sweet clover, 4 pounds of red clover, 6 pounds of domestic ryegrass, 4 pounds of meadow fescue and 5 pounds of hairy vetch. This mixture was seeded at the rate of 50 pounds per acre. The domestic ryegrass included in the mixture acted as a companion crop.

Results from the various seed mixtures used, indicate that the rate of seeding used in 1936 was possibly too light for the early control measures employed, because considerable siltation and washing occurred in the earlier waterway seedings. There has been little difference in the successfulness of the 1937 seed mixture, sown at the rate of 50 pounds per acre in 1938, and the 1939 seed mixture, sown at the same rate.

The rate at which seedings are made in drainageways should be dependent upon the completeness of the protection given by control measures employed and the possibility of the drainageway carrying large quantities of run-off at high velocities. A better cover was established more quickly by using domestic rye grass and, apparently, the rye grass will be followed by better stands of other grasses than will the companion crops previously used. This is not conclusive, as sufficient time has not passed for the making of a complete study.

The tendency of the mixtures and companion crops used in 1937 and 1938, has been toward the establishment of a dense cover by the companion crop during the first year, followed by a fair to dense cover of sweet clover with redtop and orchard grass present during the second year. A survey of seeded waterways, made two years after seeding, indicates that orchard grass and redtop are the two grasses most likely to succeed from the 1937 mixture. There are indications, however, that some of the other members of this mixture will become more prominent after two or three years. In drainageway seedings, the presence of sweet clover and orchard grass, or other stiff stemmed plants, is not desirable, but their use should probably be continued until suitable grasses are found which will grow under the adverse conditions which exist in drainageway seedbeds. These desirable grasses should lie down and provide a smooth, even surface for the storm water to flow over.

The establishment of vegetation in a few drainageways was attempted by seeding and the use of whisker dams as a protective measure. These dams were found to be effective on small watersheds up to 2 acres in area. On larger watersheds on the sandier soils, a step-like effect was obtained and the dams failed.

The methods used for the maintenance of vegetative drainageways are similar to those given for orchard terrace outlets. The use of improved disks and harrows which may be tripped in and out or lifted over the channels should be further emphasized.

Structures.

Because of the high value of orchard land, a relatively large number of permanent structures of various types have been used. Few temporary structures have been employed in orchard land, due to the fact that it has been necessary to use shrubs and forest trees in conjunction with these structures to control gullies. Control by vegetative drainageways in the orchard itself was emphasized. The use of permanent structures was confined to large, deep ravines or gullies which threatened to enter, or had already entered the orchard.

Early in the history of the project, a few semi-permanent rock wire dams were used in orchard land. These were constructed by enveloping boulders inside of woven wire fencing. Each rock wire dam was laid in a trench across the gully, so that its ends were 8 inches to a foot higher than its middle, as shown in Figure 19. In this way, storm water was forced to go over the middle, rather than around the ends of the dam. A boulder apron was provided. In some cases, water ran through these dams for a number of years, but eventually, the spaces between the rocks became filled with silt and the dam itself became partly covered with vegetation.

In the early days of the project, a few arched brick dams were built in orchards to control active gully lips. This type of dam is shown in Figure 20. The bricks used were soft and were used because they were obtained free. They were cleaned by WPA labor during the winter of 1936.



Figure 19. Woven wire boulder dam. These dams are built by enveloping boulders inside of woven wire. Eventually the cracks between the boulders became filled with silt, and vegetation has partly covered the structure. (Mich-62)



Figure 20. Low soft brick arch dam. The apron is of boulder riprap. Many of these dams have been partly destroyed by frost action on the soft bricks. The channel below and above this dam has been covered with a dense stand of vegetation. The channel below the dam has been built up by silt accumulations, so that now the dam acts as a water spreading device. (Mich-85)



The soft bricks were badly cracked and chipped by frost action during the first winter and, no doubt, the dams would have failed earlier if they had not been arched. They were not more than 2 feet high and those that have failed to date have not permitted serious erosion, because of the excellent vegetative control above and below the dams. In a few cases, the siltation of the drainageway below the dam has been so extensive that the effective height of the dam has been reduced from 2 feet to 3 or 4 inches. In other words, the dam has become merely a water spreader. Under no circumstances, would soft bricks be considered as material for permanent dams today and with the present improved methods of establishing vegetation, the use of many of these dams would not be repeated.

A number of flumes were also built with soft bricks. A picture of this type of flume is shown in Figure 21. To date, there has not been a failure of a flume, because of the action of frost on the brick, but maintenance work will be necessary in the future. The longest of these flumes was built with a reinforced concrete floor. Since 1937, flumes and dams have been built of reinforced concrete. A rectangular cross-section has been used on all flumes.

A stilling basin, designed with a buffer block and weir wall, as shown in Figure 22, was used at the lower end of all flumes. Flumes were used only where the value of the land and trees protected was over $250 per acre; where the watershed area was more than 10 acres and where storm water had to be dropped more than 10 feet before reaching a stable grade. In general, no flume was ever placed in a gully head, but the storm water was diverted around the gully head to a point where the flume could be constructed on solid ground. Consequently, only one flume has been undercut at the head end. Since this failure has occurred in the spring for two successive years, frost action is believed to be the cause. The flume is located on heavy, wet soil and during the winter, the head end is heaved up and left in a perched position in the spring when undercutting occurs. A similar flume, located on similar soil, but drained underneath, has not undercut. Steps have been taken to provide drainage for the soil underneath the flume where undercutting occurs.



Figure 21. Short head flume built with soft bricks. This type of flume has worked successfully except that the soft bricks have been damaged by frost action. (Mich-95)



Figure 22. Reinforced concrete head flume. The stilling basin consists of a buffer block in the throat of the flume with a low weir wall and apron at the end of the stilling basin box. (Mich-459)



Small concrete reinforced check dams were built according to standard specifications for this type of dam, as given by Ellison (3). They were used only where land values were high and where permanent protection was needed. However, with present improved methods of establishing vegetation, the construction of some of these dams would not be recommended today.

A number of concrete gravity dams were built for larger watersheds where the run-off water had to be dropped over 6 feet to a stable grade. In one case, the cooperator insisted that one large gravity dam be built, rather than a series of small check dams, since by building the larger dam, he could reclaim approximately a half acre of land. Inasmuch as he furnished all material and form lumber, the dam was built. Notes on design and use of gravity dams will be found in the appendix.

A new type of concrete hinged arch dam was developed on the Benton Harbor project during 1938. Only two dams of this type were constructed. One of these is shown in Figure 23. Both have worked satisfactorily. Notes on the design, construction and use of these dams appear in the appendix.



Figure 23. Concrete hinged arch dam. Each slab in the arch is hinged by using dowel bars and corrugated metal separators. Forms are adjustable and may be used repeatedly. The dam is poured in place. (Mich-370)

Conclusions.

Channel sizes should be designed for constant velocity.

Watershed areas must be controlled at the time vegetative gully control work is put into effect.

The most efficient and economical method by which vegetation may be established in drainageways where storm water cannot be temporarily diverted, is by using fencing material with wooden stakes and mulch to protect seedings.

Siltation may be serious with a brush and litter type of control.

The following rates of application are recommended: for seeding, 50 pounds per acre; for fertilizer, 300 pounds 10-6-4 per acre; marl, 4 yards per acre. As a companion crop, domestic rye grass is recommended.

A mixture of the following is suggested for gully control work: redtop, Canada blue grass, Kentucky blue grass, domestic rye grass, orchard grass, red clover and hairy vetch.

Soft bricks should not be used for permanent structures. Reinforced concrete is recommended.

It is recommended that permanent structures be used only where vegetation cannot be established or maintained.

Flumes may be used for large quantities of water where runoff must be quickly lowered over 10 feet to a stable grade.

Gravity dams may be used in narrow gullies for large quantities of water, where runoff must be dropped from 6 to 10 feet to a stable grade and where there is an abundance of rocks or boulders for building material.

Reinforced concrete check dams may be used for large quantities of water, where run-off must be dropped less than 5 feet to a stable grade.

Concrete hinged arch dams may be used for large quantities of water in wide drainageways, where the run-off water must be dropped less than 6 feet to a stable grade.

Orchard roads.

Farm roads in orchard land have always been a serious erosion problem. This is true because orchards usually are located on the uplands for desirable frost-free sites. Many orchard roads are, therefore, steep and the rush of storm water down the deep ruts left by heavy orchard equipment carries enormous quantities of soil. Orchard roads are subject to heavy traffic, both from spraying equipment and from the hauling of fruit out of the orchards. The job of maintaining these roads is not easy and if it is put off until harvest time, it adds considerably to the heavy work load of the average grower.

A number of contour roads have been laid out in the project area because it was believed to be the best method for erosion control. In established orchards, however, contour roads are sometimes difficult to lay out, unless a number of trees are removed. Where contour roads are impractical, a number of surface drains have been installed to carry the storm water from the ruts to a protected outlet along the edge of the road (Figure 24). At first, wooden troughs were built with a number of partitions, so that a serious bump would not be caused when crossed with orchard equipment. Due to the square shape of these troughs and because of the rough lumber used, they became easily plugged with silt. Some damage was also caused to the wood by heavy equipment. To remedy this, surface drains to divert the storm water from orchard roads were built of reinforced concrete (Figure 52 in the appendix). These diverters consisted of a groove approximately $3\frac{1}{2}$ inches deep and 5 inches wide, cast in a block of reinforced concrete. The concrete blocks were precast in a metal form which could be used repeatedly (Figure 53 in the appendix). They were placed across and trenched into the roadway so that the grooves in the blocks would carry the storm water to the side of the road into a sod or protected outlet, as shown in Figures 24 and 25. It was found that these road diverters should have a fall of 18 to 20 inches in crossing a 16-foot roadway. The spacing between diverters was varied from 30 to 60 feet, depending on the slope of the road. Although they must be cleaned out after each severe storm, it is much more simple to do this than to rebuild the road annually.

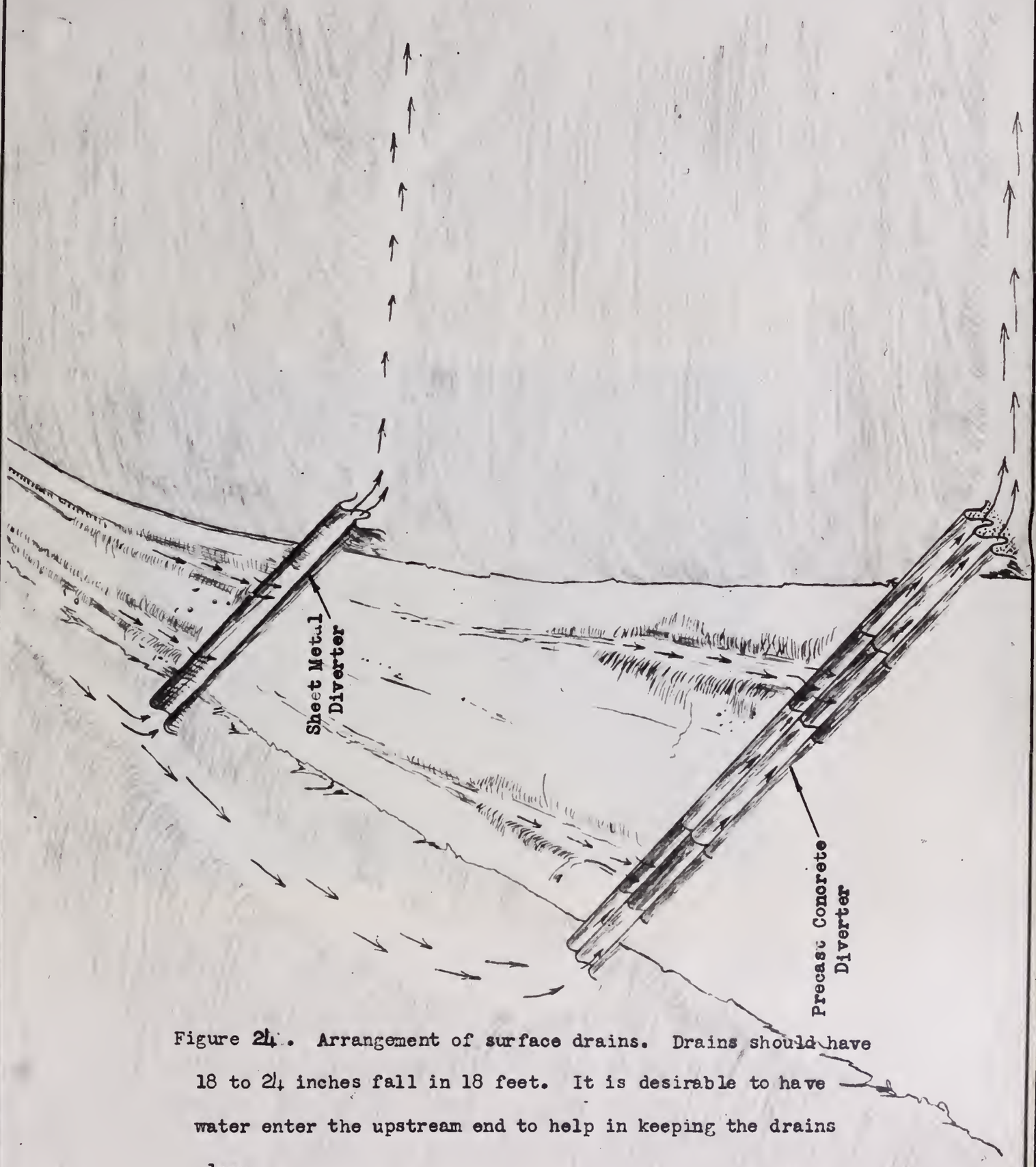


Figure 24. Arrangement of surface drains. Drains should have 18 to 24 inches fall in 18 feet. It is desirable to have water enter the upstream end to help in keeping the drains clean.

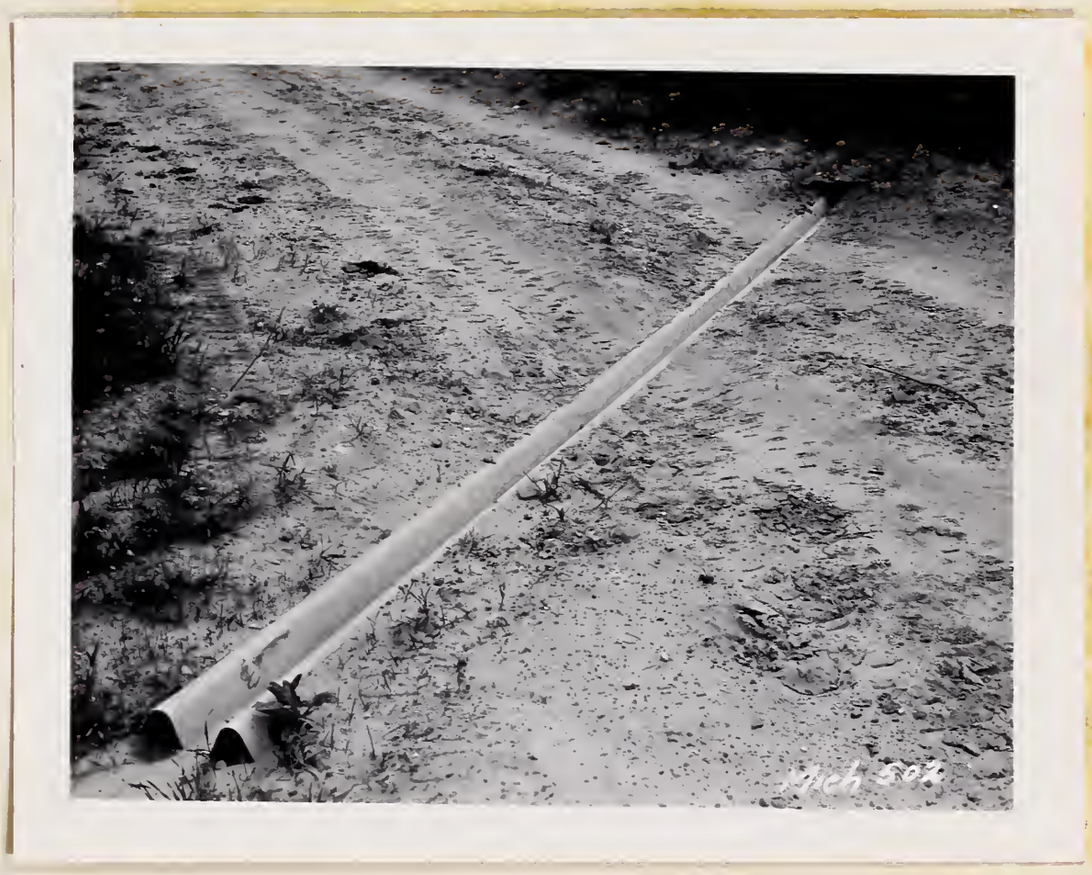


Figure 25. Metal surface drain used to divert storm water from ruts in an orchard road. This metal drain may be used as a form to make precast reinforced concrete surface drains. (Mich-502)



The location of roads in contour and terraced orchards is important and they should be planned and laid out at the same time the orchard is planned, for unless a suitable erosion-free roadway is provided, terraces and contour rows are likely to be crossed, or even the terrace outlet used as a roadway. The planning of orchard roads may be made as shown in Figure 13, but each roadway is an individual problem.

Conclusions.

Contour roads should be established when possible.

When contour or terraced orchards are planned, provision should be made for suitable erosion-free roadways.

Surface drains are recommended for roads having grades from 3 percent to 10 percent. The spacing between the drains should be governed by the slope.

Orchard roads having grades over 10 percent should be re-established to a lower grade.

Surface drains should be cleaned of erosional debris after each severe storm.

Meadows, Pastures and Cropland

Liming.

The value of liming as a measure for soil and water conservation is chiefly through indirect influences. While an abundance of lime in some soils does improve their physical condition for the absorption of more rain water, the chief benefit is due to the promotion of better vegetative cover and increased amounts of organic matter in the soil.

The need for a more general use of liming materials on many of the farms within the area, has been recognized. The sandy soils are low in organic matter and should have a soil building program applied to them; meadows, pastures and cropland are too acid for the production of alfalfa hay or sweet clover for green manure and increased yields of certain crops have frequently followed the application of lime. The use of liming materials is fundamental and essential in the rebuilding of acid soils and in the maintenance of soil fertility. Consequently, the application of sufficient amounts for the growth of alfalfa and sweet clover became one of the first requirements in farm plans for this area.

A lime requirement map of Berrien County (Figure 49) on which the project area boundaries are indicated, may be found in the appendix. About three-fourths of the land in the area requires from 1.5 to 3.0 tons of agricultural limestone per acre, to change the reaction of the soil to a range within which satisfactory stands of either of these crops may be expected.

With an abundance of low-priced marl within easy hauling distance of all cooperative farms, lime requirement has commonly been referred to in terms of "yards of marl", rather than tons of limestone. One yard of this marl is equivalent to about 1,500 pounds of agricultural limestone.

Marl has been applied chiefly by hand and by the use of manure spreaders, since there is practically no special equipment for this purpose in the community. A special marl spreader was developed and used successfully by a number of cooperators. By the methods used, good coverage with amounts less than 4 yards per acre cannot be obtained easily. For this reason, 4 yards have commonly been used as the standard recommendation. In most cases, this amount has been ample, but in a few instances, chiefly on light sands low in organic matter, additional amounts have been necessary.

Owing to the inclination to delay marl applications until a short time before the seeding of alfalfa and sweet clover, a few failures were experienced. These failures emphasized the need of sufficient time for the lime to become effective before seedings are made. Consequently, plans of conservation operations provide that marl applications be made at least 6 months before seeding.

A few cooperators were slow in realizing the importance of a liming program. No doubt, this was partially due to an occasional report of alfalfa growing on land where no lime materials had been applied. Most cooperators, however, were anxious to obtain all the marl possible at the special rate afforded by the government under their agreement and many of them have purchased and applied amounts beyond those specified in the agreement. More than 10,000 yards of marl were dug by the government and made available to all cooperators.

The effectiveness of a liming program on the cooperating farms within the project is reflected in an increased acreage of alfalfa and sweet clover, in the improvement of numerous pastures, in providing better green manure crops and in an increased amount of leguminous cover in orchards.

Conclusions.

The use of lime is fundamental and essential in maintaining and rebuilding acid soils. It should be one of the first considerations in plans for conservation operations.

Lime or marl should be applied at least 6 months previous to the time of seeding acid sensitive legumes.

Improved crop rotations.

The importance of good rotations in any cropping program for the control of erosion was well recognized when the project was established. Owing to the varied types of farming in the area, however, no attempt was made to formulate a standard set of rotations.

There is a considerable range of diversification on farms in the area. Some are almost entirely in orchards and a few are used primarily for the production of grain and livestock, but the majority are given over to various combinations of truck crops, fruit and a limited amount of crops for feed and grain. Such a wide variation made it necessary to work out each rotation to meet the specified conditions on the farm where it was to be used.

An attempt was made to provide winter cover following all clean tilled crops. Under general farming conditions, old rotations such as corn-oats-clover or corn-oats-wheat-clover were used satisfactorily on level land. Since most of the rotational land under agreement is sloping and because these rotations did not provide winter cover following corn, it was considered better to use rotations of corn-wheat-clover or corn-wheat-alfalfa-alfalfa.

Effort was made to devise long rotations with as little time as possible given to cultivated crops. With this in mind, corn-wheat and 3 or 4 years of alfalfa was the most commonly used rotation for general farming conditions.

Truck crop rotations.

The chief concern, however, was rotations for land being used for truck. Much of this was in clean tilled crops every year. On the sandy soils, which make up the greater part of the truck area, the supply of organic matter had become, or was rapidly becoming, very low, although considerable manure was being shipped in. Consequently, the need of soil improving crops in truck rotations was given first consideration.

In order to furnish an abundance of organic material to be turned under, these rotations were planned to provide, frequently, a year given over entirely to soil improving purposes. The rotation truck-truck-sweet clover was used more than any other, although a 2-year rotation of truck-sweet clover was often recommended for the lighter sands.

Under the conditions of truck growing outlined above, the improved rotations were short, rather than long. In some cases, soybeans, or a mixture of soybeans and Sudan grass, was used instead of sweet clover.

Truck growers vary in their opinions with regard to the merits of soybeans and sweet clover. Those unfamiliar with the habits of sweet clover usually prefer soybeans. While the latter do furnish a large amount of organic matter, the practice of plowing them down in the fall necessitates the use of a winter cover crop. This expense of plowing and seeding is avoided where sweet clover is used.

Growers who strive to get their cantaloupes matured for an early market, claim that plowing down alfalfa or sweet clover in the spring delays maturity of their melons. For that reason, they prefer soybeans in their short rotations.

Rotations were started which included three years of strawberries, followed by one or two years of sweet clover. Owing to various factors, however, the use of sweet clover with strawberries has been questioned. First, the soil reaction necessary for the growth of sweet clover is also favorable to root rot in the strawberry; second, the pH range preferable for strawberries is below that required for sweet clover; and third, when sweet clover is allowed to mature seed and is subsequently plowed under, the volunteer stand that often follows may be sufficiently dense to require an excessive amount of hand labor to eliminate it from the strawberries.

The last is a valid objection to a crop of biennial sweet clover remaining in any truck rotation for two years in succession. With proper management of the sweet clover, this objection would not arise. However, any management practice to prevent self-seeding would involve labor at a time when other crops would be requiring the full time of the grower and consequently, is likely to be delayed too long to be effective.

With due consideration of these factors, a two-year rotation of truck-sweet clover is now being recommended, rather than a four-year rotation of truck-truck-sweet clover-sweet clover. About the shortest, practical strawberry rotation, is three years of strawberries, followed by one year of a coarse growing legume. Until more is known regarding the outcome of strawberry rotations, including sweet clover, it is best to use soybeans as the legume.

Improved rotations have been effective as a soil conservation practice, by reducing the acreage of clean tilled and semi-erosion resistant crops. Also, the acreage of fall plowing has been reduced, with a consequent increase of winter cover provided by crop residues.

The details of a good soil building rotation for sandy soil, as well as the beneficial effects, are shown by records of melon and tomato yields on the Dominick Stoffle farm. Soil improving crops in melon and tomato rotations increased yields and improved the quality of Mr. Stoffle's produce. Prior to 1936, he had grown truck crops annually for at least 10 years and yields were declining. Mr. Stoffle asked the Soil Conservation Service to help solve the problem of wind and water erosion on his sandy fields. An adequate liming and crop rotation program was prescribed in the complete farm plan to increase soil fertility, control erosion and increase profitable production.

In 1936, Mr. Stoffle marled his fields and started growing a mixture of soybeans and Sudan grass in a two-year truck rotation. After truck harvest, he sowed rye, disking it into the soil in late May or early June the following year, preparatory to planting a mixture of soybeans and Sudan grass. Then this mixture was disked into the soil in August, or about 60 days later, and rye was again sown for over-winter cover. The following spring, the rye was plowed into the soil, along with the decaying organic material from the previous soil improving crops, in preparation for another truck crop. Thus, a truck crop and three soil improving crops are grown in two years.

This rotation provides cover for approximately 18 months out of every two years. It gives protection during the months of high winds and improves the erosion resisting qualities of the soil when the residues of rye, soybeans and Sudan grass are incorporated with the top layer of soil by disking and plowing.

Small farm operators often doubt whether they can afford to decrease truck acreage in favor of soil improving crops. According to yield records kept by Mr. Stoffle, this problem was easily solved after the first or second year in such a rotation, because the melon and tomato quality improved and yields increased to more than double the yields prior to the use of this rotation.

Conclusions.

For general farming, long rotations such as corn, small grain and three or four years of an alfalfa and smooth brome grass, should be used.

For truck farming on very light soils, a short (two-year) rotation, consisting of one year of truck and one year of soil building crop (sweet clover or a mixture of soybeans and Sudan grass) is recommended.

For strawberries, a four-year rotation, which includes three years of strawberries, followed by one year of a mixture of Sudan grass and soybeans, can be used.

Strip cropping.

Strip cropping has been used to a limited extent on this project. The plans of conservation operations for 19 farms provided for some form of stripping. While most of this was contour strip cropping to control water erosion, some of it was field stripping to control both wind and water erosion. Most of the land on which wind stripping was planned originally, has been taken out of regular rotation and is now being kept in soil improving crops.

Contour strips were laid out under various conditions of soil, slope and erosion, varied between 60 to 100 feet in width and between 350 and 2,700 feet in length. Owing to the small size of farms and fields, areas contour stripped were frequently worked into rotations with land not stripped. Also, due to shortness and irregularity of slope, a single contour strip sometimes appears alone, rather than in a series of adjoining fields (Figure 26).

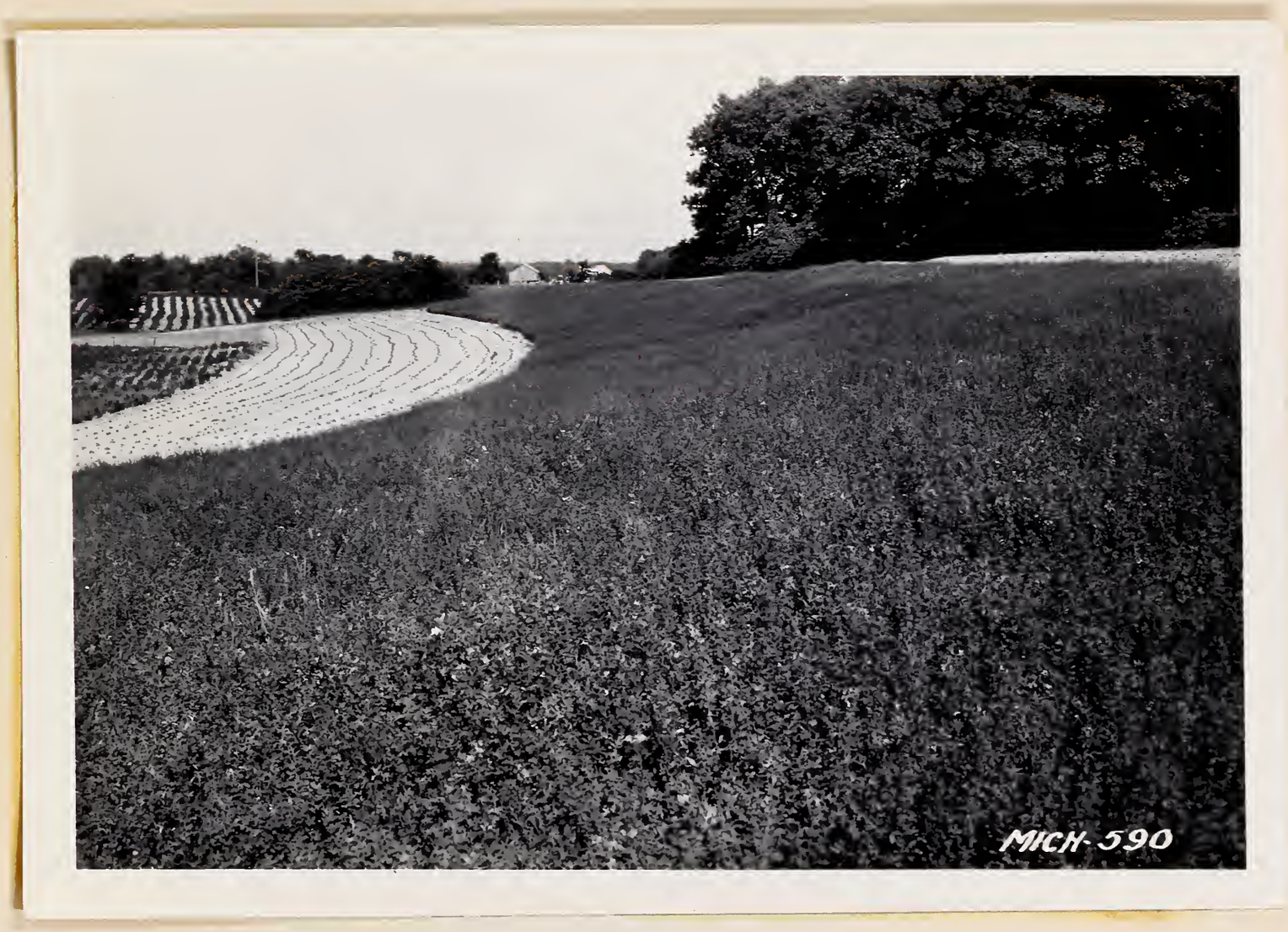


Figure 26. Contour strip for truck rotation. Area in alfalfa too steep for cultivation to remain as hay land. (Mich-590)

In general, contour strip cropping was limited to slopes of 0 to 7 percent. Occasionally, however, small areas of 7 to 12 percent slopes were stripped.

This method of checking erosion has not been used extensively enough on the Benton Harbor Project to warrant complete recommendations under different conditions of soil, slope and erosion. Sufficient observations have been made, however, to suggest that the strips should not exceed 80 feet in width. Rilling has been infrequent in the cultivated strips, even during the heaviest rains, and siltation has seldom extended as much as 8 or 9 feet into strips of hay or small grain.

Farmers who have the most extensive systems of contour strip cropping are well satisfied with results. Mr. Lewis Umphrey, after four years of experience, regretted the loss of part of his strips for general farming when he contour planted an orchard there.

When his system of contour strips was laid out, Mr. Emerson Cryan remarked: "It looks crazy to me, but I'm going to try it." Three years later, he said: "It has done a good job of holding the water and soil and has given me more available feed. I wouldn't go back to the old system. In 1938, I harvested a six-acre strip of tomatoes without driving into the field." This was done by carrying the tomatoes to the edge of the adjoining meadow strip.

Mr. Mark Vladic noticed that a heavy rain did some damage to his strip cropping. He observed, however, that it was nothing in comparison to what would have happened if he had planted his corn up and down the slope, as he had been doing. Asked about cultivating his corn in crooked rows, Mr. Vladic replied: "It was hard to get used to at first, but the more I do it, the better I like it."

Conclusions.

Width of strips should not exceed 80 feet.

Width of strip should vary with the slope of the land. As the slopes increase, the proportion of close growing crops in rotations should be increased.

Contour cultivation.

Contour cultivation of cropland was confined primarily to fields being contour strip cropped and was effective in controlling soil erosion when used in this way (Figure 27). In a few fields, contour cultivation was the only mechanical soil conservation practice attempted.

The success of this practice alone has depended on a number of factors. Where the fields were small, with short, gentle slopes, and where cultivation was on the true contour, satisfactory control was obtained. However, where slopes were choppy, or contained numerous waterways, so that cultivation frequently was off contour, control was not as good as desired.



Figure 27. Cantaloupes planted for contour cultivation. Truck growers find "curved row" farming does an effective job of erosion control. (Mich-331)

In general, contour cultivation has proved beneficial in controlling erosion and should be recommended, although on broken slopes, small areas may occasionally occur where it will cause a greater concentration of water and consequently, accelerate erosion. This can usually be remedied by the use of sod waterways. Farmers are slow to realize the importance of sod in such places. They are prone to plow and cultivate drainageways. Much educational work is needed to foster the establishment and maintenance of good sod waterways and the use of field machinery with power lifts should be encouraged.

Some cultivation, described as "across the major slope", has been practiced. This has furnished some erosion control and certainly is a better practice than "up and down hill" cultivation. The disadvantages are similar to those described above for contour cultivation on broken slopes where contours are not always followed.

Permanent base lines have not been established in the fields under contour cultivation. In a few instances, such lines exist naturally. The continuation of the practice in the future depends on the establishment of new field boundaries and base lines.

Conclusions.

Contour cultivation is not entirely satisfactory as an erosion control measure on long slopes or on choppy slopes when used alone, but it is much better than up and down hill cultivation.

It is successful only on short, even slopes, where cultivation is maintained on the contour.

Cover crops on cropland.

A tremendous increase in the seeding of winter cover crops has been the outstanding accomplishment in the application of soil conservation practices to cropland on this project from the point of acres affected. In addition, there has been a material increase in winter cover furnished by crop residues due to improved rotations. This cover has been improved, in some instances, through an increased use of legume seedings, in small grains, for green manure purposes. Much summer cover has been provided through the growing of more summer crops such as soybeans and Sudan grass for green manure.

Cropping plans provided for winter cover as much as possible after all clean tilled crops. With corn and late truck crops, seeding of cover has not always been feasible. The large acreage which has been seeded has been influenced, no doubt, by the considerable acreage of early truck. Seldom is there a good reason for land in early truck being without adequate vegetative covering to protect it against erosion during the following winter.

Rye is the common winter cover crop for cropland on the project. In some instances, where fields are subject to wind erosion, summer crops for soil building purposes are permitted to stand over winter. This has been recommended primarily to avoid the possibility of poor winter and spring protection due to insufficient growth of the fall seeding following a late turning down of the green manure crop. For a similar reason, leaving of summer grasses and weeds for over-winter cover, instead of disking them down and seeding a cover crop, has frequently been encouraged following the harvest of late crops.

When early seedings for cover are possible and where the subsequent plowing of the cover crop would be late enough for considerable growth in the spring, the inclusion of a winter legume, like hairy vetch, has been recommended. This has not been followed, however, to any extent.

Early seedings (late July and August) of small grain for winter cover in 1938, were almost entirely destroyed by rust. Material damage occurred again in 1939, but not to the degree it did during the previous year. Where this occurred, the fields were practically without cover during the winter months. The inclusion of a winter legume in the seeding on such areas would have provided at least a fair amount of protection.

Cover crop seed is usually broadcast and then dragged in with a spring tooth harrow, or disked in. This method is used because of a lack of grain drills in the fruit belt. Where drills have been used, better stands have resulted.

The use of cover crops as a soil conservation practice has provided an amount of protection against erosion by both wind and water that is difficult to measure. Their value in retarding soil losses is readily observed in the field. When fields supporting good cover crops are compared to others similar with respect to soil, slope and erosion, but without cover, the benefits are quite obvious.

Conclusions.

Truck land should be seeded as early as possible to a suitable cover crop. Better stands will be obtained if the seed is drilled into the ground. Drilling should be on the contour as much as possible.

Soybeans and Sudan grass are recommended for summer cover on areas affected by wind erosion.

If truck is harvested too late for a cover crop to be grown, weeds should be allowed to develop.

Green manure crops.

Seeding of sweet clover in small grain, of soybeans for soil improving purposes during the summer and of rye for winter cover, all have been influential in effecting a material increase in the use of green manure crops on farms under cooperative agreement.

The use of green manure is closely associated with the use of cover crops. Cover crops furnish considerable quantities of green manure and green manure crops provide good cover. Both are important in many of the improved rotations used on soil conservation demonstration farms. One of the best examples of this is the two-year rotation of truck-soybeans used on the lighter soils. The soybeans furnish an abundance of organic material when plowed down in the fall before the plants are matured. A cover crop, usually rye, is seeded after truck and is turned under before the soybeans are planted. Another rye, or similar cover crop, is seeded after the soybeans have been disked down and this in turn is plowed down before the next truck crop is planted. Accordingly, this system furnishes three green manure crops in two years.

Some objection might be made to this use of soybeans, on the basis that they would not make sufficient growth on the sands to provide any worthwhile amount of organic matter. This is true on infertile areas. On such areas, it would be better to start a soil improving program by liming and then seeding sweet clover. However, where commercial fertilizer has not been used on truck crops, the residual effect has been sufficient to produce a good growth of soybeans (Figure 28).

Sudan grass is sometimes seeded with soybeans. Such an inclusion is well recommended, since it increases the amount of organic material for green manure. The material produced by this mixture probably decomposes somewhat more slowly than soybeans alone and consequently, should have a more lasting effect, not only from the physical benefit it provides, but through a more gradual release of plant food as well. The benefits derived in the form of increased crop yields following the use of this system have been noted under "Truck crop rotations."

If the land has been limed and sweet clover is substituted for soybeans, seeding may be done in the spring following truck, using the rye as a companion crop. Some means should be provided to cover the seed, particularly on sandy soils. Usually, light disking will suffice and do little damage to the rye. Later, the rye may be clipped.



Figure 28. Heavy growth of soybeans and Sudan grass being turned under for green manure or soil building purposes. (Mich-612)

With this system, no cover crop is seeded in the second year of the rotation, since the sweet clover stands over winter and furnishes an abundance of green manure the following spring. This effects a considerable saving in labor and seed cost. It also eliminates exposure of the soil to wind erosion twice during the second year of the rotation, as is the case where the rotation truck (cover)-soybeans (cover) is used.

Occasionally, hairy vetch is mixed with the rye seeded for winter cover. Where conditions are favorable, this mixture furnishes an abundance of green material to be turned under in the spring. On soils subject to blowing, and where a soil improvement program is being practiced and economy is desired, the mixture might well be left until seed is matured and then disked down in such a manner as to leave a trashy surface. Volunteer stands from the seed disked in would furnish new winter cover and fresh organic material to be turned down the following spring. The trash and cover crops combined would practically eliminate exposure to wind erosion during this period of soil improvement. While this system has not been followed in detail on the project, it has been approached closely enough to warrant further consideration.

. Conclusions.

Green manure crops, as well as cover crops, are fundamental in good rotations to maintain soil fertility.

The use of a two-year rotation of truck and a mixture of soybeans and Sudan grass for a green manure crop, supplemented by annual cover crops of rye and hairy vetch, is recommended. This provides three green manure crops to each cultivated crop.

More growth can be obtained by using commercial fertilizer.

Terracing.

The terracing of land, other than that in orchards, was confined to four jobs in the project area. Inasmuch as two of these are in perennial hay or pasture land, little information regarding this type of terracing has been gathered. The use of terraces on hay or pasture land has been satisfactory to date and it is believed that they will aid in the re-establishing of vegetation on these sites whenever reseeding becomes necessary. They have also benefitted the vegetation by conserving moisture.

Inasmuch as the terraces on other than orchard land were built during the early days of the project, the absorptive type cross-section was used. The same difficulty as reported under "Terracing in orchard land" was experienced in obtaining the proper cross-sectional area on the sandier soils. One of these early terraces was so badly sectioned and had such an excessive grade, that it was necessary to rebuild it. In the rebuilding process, the drainage type cross-section was used and the grade was reduced to 0.4 percent. The proper cross-section was easily obtained and the terrace has functioned satisfactorily to date.

One terrace system, located on Nappanee soil, is noteworthy because this soil is easily puddled if worked when wet and the subsoil is supposedly unproductive. These terraces were built in midsummer, however, so that no puddling would occur and since the field was badly eroded, much subsoil was exposed. By using 10-6-4 fertilizer, at the rate of 300 pounds per acre, a good stand of Sudan grass was established during the same year. Caution should be exercised whenever this soil type is terraced.

The only system located on cropland was on Coloma loamy sand, low in organic matter. This system consisted of two terraces which traveled around the inside of a pothole or pit having an area of approximately 5 acres. The field has been used for truck continuously, with a winter cover crop of rye and vetch being sown annually. Although the truck was planted and worked parallel to the terraces, the rain of June 21, 1939, with an intensity of 5.1 inches per hour, caused the lower terrace channel to become approximately half filled with sand. It was cleaned out successfully by using a V-drag and slip scraper. The spacing of the terraces was as recommended for the North Central States (12) for the given slope, but it is believed now that a closer spacing would have helped considerably.

Conclusions.

Drainage or channel type terraces are believed to be the best suited to cropland in the area.

Maximum grade for cropland terraces should not exceed 0.4 percent.

Nappanee soil should not be terraced when there is any danger of puddling.

Terrace outlets.

In general, the same methods were used in design and construction and to establish vegetation as were used in orchard terrace outlets. Inasmuch as terracing on other than orchard land was confined to a few jobs, little information has been gathered regarding these outlets. Larger drainage areas were encountered than with orchard terraces and consequently, run-off was diverted out of the channel in some cases and carried temporarily along the outlet until a seeding was established. In other cases, where this could not be done, the outlet was sodded solid and the sod fastened down by using old cattle fencing and wooden stakes. Two outlets were built by using both vegetative and structural control. With the improved methods of establishing vegetation, it is doubtful whether the mechanical structures would be used if the jobs were repeated.

Other problems, such as maintenance, are the same as for orchard terrace outlets.

Conclusions.

Where possible, outlets should be established prior to the terracing program.

Storm water should be diverted temporarily from the outlet, if possible, until seedings are established.

Where sodding is used to establish a vegetative cover, it should be fastened down by used fencing material.

Mechanical structures should be used only where vegetation cannot be satisfactorily established or maintained.

Diversion channels.

Because of the irregular slopes and the hummocky conditions which exist in the project area, a single diversion channel, used in connection with strip cropping on medium length slopes, is an efficient aid in controlling erosion. Where irregular slopes and hummocky conditions occur, the length of slope is usually not great, but terracing and contour strip cropping can be put into effect only with great difficulty. A diversion channel may be located in a meadow strip and although the channel itself may be extremely irregular, the edges of the meadow strip may be made to follow the channel so that curves are more rounded.

The best example of this type of use of a diversion channel is on the Anna Weber farm in Bainbridge Township. This diversion channel (Figure 29) is in a meadow strip approximately 40 feet wide and is located at the point where the slope of the field changes abruptly from 4 percent to 12 percent. The length of slope is such that one strip is located above the 40-foot meadow strip in which the diversion channel is located and two contour strips are located below the channel. The average width of these strips is approximately 65 feet.

Asked which practices had worked best on her farm, Mrs. Weber pointed to the diversion channel and said: "That terrace has helped more than anything."

Inasmuch as the soil on the Weber farm is sandy and subject to wind erosion, the ridge of this diversion channel was planted to a pine windbreak.



Figure 29. Diversion channel in meadow strip used near the top of the slope in a contour strip cropping system. (Mich-496)



The design of diversion channels on cropland has been for a constant velocity by using a uniform cross-section and a variable grade. The velocities designed for are the same as were given for orchard land. Where diversion channels have been used to divert run-off water from gully heads, the control of soil erosion in the watershed above is important, especially on the sandier soils, because of the severe sanding of the channel.

Maintenance of diversions, on land other than orchard land, has been similar to the maintenance of orchard diversion channels and the same recommendations apply.

Conclusions.

Diversion channels are best used in a meadow strip near the top of a slope, in connection with strip cropping on medium length, irregular slopes.

Watershed control by vegetation is necessary if the diversion is located down the slope as a diversion for a gully head.

Gully control.

The same methods and seed mixtures used on orchard land were used in establishing vegetation on drainageways on other land.

Because of the difference in land values between orchard land and other land, the use and type of structures were governed by land values. For this reason, more temporary structures were used on other land.

The first gully control work done on the project area in the fall of 1935, was in a gully which existed on a farm in Benton Township (Figure 30). The gully had formed during a cloudburst in the summer of 1934. At the time work was started, it was 15 feet deep and 80 feet long.

Because a funnel-shaped gully was formed in an east-west direction, with the larger end facing the west, the prevailing southwest winds were compressed in passing through the gully, making them most erosive. As a result, both wind and water ercsion were active in the same gully.

To control both types of erosion, temporary dams were built of posts, poles and brush and the gully banks were sodded in strips so that the strips formed 4-foot squares. The sod was laid in this manner to control both the wind erosion up the gully and the water erosion down the gully banks, as shown in Figure 31. The gully itself was planted to black locust and fenced out. The success of this type of control is shown in Figure 32, taken 18 months after control measures were put into effect.



Figure 30. Same gully as shown in Figures 31 and 32. Picture was taken before control work was started and shows the result of one cloudburst on a small watershed of Plainfield loamy sand. The gully was also affected by wind erosion. (Mich-6)





Figure 31. Sod strips used to control both wind and water erosion. Sod strips across the bottom of gully are partly buried. Temporary header dam of posts, poles and brush was used. The gully was reforested with black locust. (Mich-75)





Figure 32. Same gully as shown in Figure 30, taken 18 months later. Note fence in the foreground which was used to fence out gully. (Mich-6A)

The most promising type of temporary structure used was the sod dam. This dam was constructed by placing poultry netting and 10-gage galvanized wire behind 6-inch posts set on 2-foot centers. Sod was placed face out behind the poultry netting. The height of these dams was not over 18 inches. A weir notch of suitable size and a sod apron were provided by holding the sod in place with poultry netting and wooden stakes. This type of dam is shown in Figure 33.

Observation of these dams revealed that they held up well during a rain which occurred the winter following their installation. As the particular dams noted on this survey faced north, they remained frozen during the rain. This, no doubt, helped considerably.



Figure 33. Temporary sod dam built by facing sod out against poultry netting which is reinforced by 10-gage smooth wire. (Mich-83)



During 1938, two drop inlet flumes were constructed by using old spray drums which were fastened together to form the flume part of the structure. A concrete drop inlet was built at the top of the flumes and a stilling basin was built at the bottom. Both ends of the spray drums were cut out; one edge of the drum was crinkled similar to stove pipe so that the drums could be fitted together. They were bolted in place and the joints filled with plastic asphalt. The drums received two coats of an asphalt base paint inside and out before they were installed.

The reinforced concrete catch basin at the top, together with two diversion channels, were used to lead the run-off water around the active heads of gullies into the spray drum flume. The stilling basin of reinforced concrete at the lower end was built so that the discharge from the spray drum flume could cause no further damage. The drums themselves were covered with dirt and the gully was reforested with black locust.

This type of structure was used because the land value protected was not high enough to warrant the installation of a more permanent structure. The life of the spray drums, under the conditions given, is not known, but it is believed that maintenance will not be difficult or costly.

The cost of this type of structure, including the concrete catch basin and stilling basin, was $2.75 per lineal foot of flume. The methods used in construction of the flume are shown in Figures 34 and 35.



Figure 34. Spray drum flume used to carry storm water down deep gully in Plainfield loamy sand. A concrete catch basin was used at the top end and a stilling basin similar to the one shown in Figure 22 at the lower end. (Mich-324)



Figure 35. Same flume as shown in Figure 34. The ends of the spray drums were cut out and one edge crinkled similar to stove pipe so the drums could be fitted together. The drums were bolted together and the joints filled with plastic roof cement. (Mich-325)



Conclusions.

Sod strips have provided satisfactory erosion control for sand gullies having small watersheds and where wind erosion was a factor. It is believed, however, that as good control could have been obtained more economically by seeding and mulching, with the mulching material held in place by used cattle fencing.

Sod dams have worked satisfactorily as temporary structures for watersheds up to 5 acres in area. Their use should be limited to the sandier soils where water conservation is needed to support a luxuriant sod cover.

Spray drums have been used successfully to conduct storm water. Their economic value will depend upon the amount of maintenance needed. No information on the amount of maintenance is available at this date. It is recommended that spray drums be used only on the sandier soils where the corrosive action of ground water is at a minimum.

Mulching.

Mulching, as described here, will cover its use as an aid in establishing seedings on critically eroded areas in orchards and fields.

In most instances, it is difficult, if not impossible, to establish vegetative cover on badly eroded sites with the usual methods of liming, fertilizing and seeding. In addition to the usual methods, a thin layer of mulch should be provided. One area treated in this manner was in a mature apple orchard on Hillsdale sandy loam, with slopes ranging from 1 to 18 percent and having severe sheet erosion. Some areas had occasional or frequent gullies.

Marl was applied at the rate of 4 cubic yards per acre during late winter. During the week of April 20, 1937, a good seedbed was prepared by disking and harrowing. Scarified white sweet clover was then broadcast at 12 pounds per acre, with a bushel of oats per acre. Part of the seed was harrowed and part of it lightly disked into the ground. Two hundred and fifty (250) pounds of 10-6-4 fertilizer per acre were applied at the time of seeding. A medium coarse mulch, ranging from 12 to 20 inches in length, was applied to part of the orchard, at the rate of approximately 5 tons per acre, immediately after seeding. The mulch was applied by hand, being spread in a thin layer over the entire surface (Figure 36).

The 1937 growing season was wet, 17.72 inches of rain falling during the 5-month period from May 1 to October 1. Much of this precipitation came in rains of high intensity. Measurements taken on June 16 showed that the oats on the unmulched area ranged from 4 to 9 inches high, while those on the mulched area ranged from 12 to 20 inches high. There was a corresponding difference in the sweet clover.

In September, the plants were counted and their height measured. Six random samples were taken from areas containing 169 square inches each, three from each area. The unmulched area sampled was within 50 feet of the mulched area. The data shown in Table 1 were obtained.



Figure 36. A thin layer of mulch applied after liming, fertilizing and seeding. This has proved successful for establishment of vegetation on critically eroded areas. (Mich-268)

	Percentage of Slope	Number of Plants Per Unit Area	Height Range in Inches
Mulched	3	12	9 - 12
	10	8	6 - 13
	15	11	10 - 15
Unmulched	5	2	$2\frac{1}{2}$ - 4
	5	3	4 - 6
	5	5	$\frac{1}{2}$ - 6

Table 1. Effect of mulch on sweet clover seeding.

A mulched strip 30 feet from the top of a 14 percent slope caught and held much of the soil which washed from the unmulched area above, deposition measuring 2 inches in some places. Soil from rills (1 to 4 inches deep) formed in the unmulched area, was dissipated in the mulched area. There was little evidence of sheet erosion where mulch had been used (Figure 37)

Soils with sandy clay or clay subsoil, which are devoid of topsoil, tend to bake or develop a hard, relatively impervious surface, which will not absorb water readily. Any material on the surface that will tend to hold the rainfall long enough to allow penetration into the soil, will be of great benefit. It is evident from these trials that mulch used in this manner causes a greater amount of water to penetrate into the soil, minimizes evaporation losses and prevents seed from being washed down the slope, thus making the difference between seeding failure and success.

Conclusions.

Mulch, at the rate of approximately 4 tons per acre, should be used to establish seedings on badly eroded sites, especially on the heavier soil types.

The use of light mulch in establishing a seeding may mean the difference between success and failure.



Figure 37. Mulch applied in a thin layer after liming, fertilizing and seeding to sweet clover, meant the difference between success (background) and failure (foreground) in this critically eroded orchard. (Mich-348)

Pasture improvement.

Pasture acreage figures are low for the farms cooperating on this project. Much of the land in the area is unfenced and numerous farms have no pasture or livestock. A few have only one or two head of livestock and these are pastured chiefly by tethering along the roadsides and field boundaries. Frequently, the areas pastured are low and wet.

Native pasture is principally Canada and Kentucky bluegrasses. White clover and in some instances, low hop clover, have appeared quite abundantly along with these grasses, when seasonal conditions have been particularly favorable to the growth of clovers.

The bluegrasses usually become dormant soon after the middle of June and remain in that condition until about the first of September. The autumn of 1939 was drouthy and these grasses gave little fall pasture until late in October of that year.

Pasture improvement has been made principally through the use of a mixture of alfalfa and smooth brome grass, as recommended by the Agricultural Experiment Station, Michigan State College. Seeding of this mixture for pasture shortly after the project started subsequently proved so satisfactory that the mixture has almost become the standard recommendation for upland pastures here.

The principles of this pasture seeding are shown in the experience of Delvin Borst, a cooperator. He reported that alfalfa and smooth brome grass furnished more pasture than any other grass or grass mixture he ever had used. His 5 acres of hillside pasture, established in 1937, carried nine cows from May 10 to September 1. This was more pasturage than his old bluegrass pastures had produced.

To avoid exposing the whole hillside to washing at one time, it was divided into two approximately equal areas and seeded at different times. Rotation grazing was practiced.

Some of the low, wet areas have been improved as pasture by seeding Reed canary grass. Where good seedbeds had been prepared, excellent stands were obtained from spring and summer seedings. Seeding on poor seedbeds, or with no seedbed preperation, has been unsatisfactory.

So that new stands of this grass will survive the first winter after seeding on the peaty mucks in this area, it is important that a good root growth be made during the first season. A good top growth left over winter appears to afford considerable protection from heaving. To encourage both a good root and top growth, no grazing should be permitted until the plants become well established, preferably not until the second year. Well established stands have furnished an abundance of summer forage.

Little emergency pasture has been provided, although one or two cooperators are using Sudan grass each year.

Where commercial fertilizers were used on bluegrass pastures, no evidence of any benefit has been apparent, except following applications of nitrogen.

Conclusions.

An alfalfa and smooth brome grass mixture is recommended for upland pastures.

To obtain good Reed canary grass stands on wet areas, it is recommended that a good seedbed be prepared and that no grazing should be permitted until the second year.

Improved hayland.

The percentage of farm land being used for hay production, before agreement, on farms cooperating with this project, was low when compared either to a similar percentage for the county or to a 60 farm sample taken in the project area. Most of the hayland grew alfalfa, but a little clover and mixed hay were grown as well.

Under cooperative agreement, the acreage used for hay was practically doubled. The increase was due partly to improved rotations including more alfalfa, but was brought about chiefly by the transfer of considerable cropland to meadow. This transfer in land use was made to provide a protective cover on slopes which were subjected to considerable erosion when used for cultivated crops (Figure 38).

Most of the new seedings were alfalfa, or the mixture of smooth brome grass and alfalfa described under "Pasture improvement." This mixture, containing a sod-forming grass, effects better erosion control than does alfalfa alone. Some clover, and in a few instances, complex mixtures, were seeded. On one farm, Reed canary grass is being used for hay. It has furnished a good yield per acre and according to the farm operator, cows ate the cured hay in preference to pasture.

Since a considerable acreage of land transferred to meadow had a low fertility level, the application of liberal amounts of fertilizer was encouraged with all seedings. Frequently, the fertilizer was furnished by the government to insure a good cover. Recommendations by the Agricultural Experiment Station, Michigan State College, were followed as to kinds and amounts to apply.



Figure 38. Steep slope seeded for hay production. When used for clean cultivated crops, slopes of this kind are susceptible to severe erosion. For proper land use, they should be protected by a good vegetative cover. (Mich-140A)

The use of needed quantities of liming materials some months prior to the seeding of alfalfa has been insisted upon. A discussion concerning the use of lime on the project appears elsewhere in this report.

Although all hayland is not on slopes requiring continuous cover for erosion control, where good meadow seedings have been obtained for this purpose, soil wash has been stopped effectively. The judicious use of fertilizer and lime with good seedbed preparation has, no doubt, been important in bringing this about by providing a high percentage of successful seedings.

Conclusions.

A mixture of alfalfa and smooth brome grass affords good erosion control on slopes that should be used for perennial meadow.

On badly eroded lands, heavier applications of fertilizer should be made in establishing seeding.

Recommendations by the Michigan State College for seed rates and fertilizer and seedbed preparations should be followed.

Excess hay may be used for mulch in orchards.

Woodland

Forestry and land use.

Indiscriminate clearing of all land, in favor of agriculture, may lead, eventually, to such serious erosion that the land becomes unsuitable for cultivation. On this basis, it was evident that much land in the project area should be either reforested or maintained in the woodland cover already existing.

Both the soil type and the steepness of slope are factors determining the erodibility of a site. Consequently, the combination of certain soil types with certain slopes, indicated the areas to be maintained in woodland cover for the prevention of erosion (Figure 39).

In general, on slopes exceeding 25 percent, the soil can best be held in place over a long period by woodland cover. Under good systems of management, slopes of 25 percent or less can be successfully controlled by grass cover.

It is estimated that there are about 2,000 acres of native woods within the project area. Of this, about 360 acres consist of steep slopes which, for good land use, should be maintained in forest. In addition, there are approximately 750 acres which should be reforested to place other steep land in its proper use (Figure 40).



Figure 39. Indiscriminate cutting has resulted in the removal of nearly all the desirable trees. This ravine needs a good protective woodland cover. (Mich-45)





Figure 40. Proper management of this woodland has helped provide maximum yields and a continuous crop which will protect this steep slope from erosion. (Mich-252)

Reforestation for land reclamation purposes.

Wherever erosion has depleted the productivity of soil to an extent that the areas affected are not suited for agriculture, the land in general should be reclaimed by reforestation. Reforestation, as a reclamation measure, constitutes a corrective action, while reforestation as a land use measure, should be considered a preventive action. The steepness of slopes, although important, does not play a prominent role in the determination of areas on which forest plantations are needed as corrective land use measures. The reason for this is that the improper use of land in the past has induced, in many instances, erosion conditions requiring at present land reclamation on potential agricultural land. The kind to be reclaimed consists of some areas affected by severe sheet erosion, in conjunction with slight gully erosion, as well as areas affected by severe gullying and the various types of severe wind erosion.

The 1935 analysis of certain economic and physical factors relating to the Benton Harbor Project indicates that about 20 percent of the project area, or about 7,000 acres of land, are affected by erosion which is severe enough to make the land virtually useless for agriculture. From a reclamation standpoint, 125 acres were reforested. This is 1.8 percent of the land area under cooperative agreement (Figure 41).



Figure 41. A steep slope reforested with a mixture of red pine, Scotch pine and Norway spruce, to reclaim eroded land and protect adjoining valuable fruit land. (Mich-616)



Windbreaks.

During the spring months especially, when much of the soil is without a protective cover of vegetation, strong winds cause a large amount of erosion. This is particularly true in the northern area of the project, where soils are predominantly sandy.

Windbreaks, as a means of controlling some of this erosion, have been little used. Old hedge fences of Osage orange have served to a certain extent as windbreaks, but most of them have been removed.

In working out plans for soil conservation practices on farms under cooperative agreement, effort was made to include windbreaks as much as possible. As a result, more than 12 percent of all farms signed now have windbreaks started. In all, about 4 miles of windbreaks have been planted on 16 farms.

The width of a strip of land protected by a windbreak is equivalent to about 15 times the height of the windbreak. Therefore, 4 miles of established windbreaks, upon reaching a height of 60 feet, should protect about 400 acres of land.

No cultivation has been recommended, other than hoeing out weeds and sprouts about the young trees. In some places, where blowing sand is likely to bury or uncover the small trees if they are unprotected, the natural vegetation of grasses and weeds makes cover that is highly desirable. The use of large transplants eliminates most of the competition from these plants.

Direct returns from timber.

Because landowners in the project have thought returns from timber were low in comparison with the returns from fruit and other agricultural products, they have given little attention to woodland management.

In connection with the marketing and raising of fruit, however, various wooden containers, as well as posts and props, are needed. Records available from the Benton Harbor fruit market show that the number of bushel baskets alone used in connection with marketing of peaches, apples and pears, amounts on the average to about 3,100,000 yearly. It is estimated that the number of baskets used to market the horticultural crops produced within the project area is equivalent to about 353,100 pieces. Baskets are sold for about 15 cents each, consequently, the value of baskets used on the project is about $53,000 yearly.

Records kept on 71 farms under cooperative agreement show that on these units, there are about 26,000 fence and approximately 66,000 vineyard posts in use. Furthermore, about 4,900 posts of both types are necessary for yearly replacements. Since local sources of post timber are almost exhausted, prosperous farmers use shipped-in posts, consisting of either white cedar or steel. Less prosperous landowners use almost any available timber. Because of this, the post maintenance cost on the low income farms is relatively high (Figure 42).



Figure 42. Black locust planted on eroded hillside. This is a future source of many durable fence posts. (Mich-339A)

It may be argued that the wooden posts are being replaced by steel posts, because of cheapness and the higher durability of the latter. Information available shows, however, that the most expensive wooden posts (white cedar) are cheaper than steel posts. The durability of cedar posts is about the same as that of steel posts.

The average local price of cedar posts is about 25 cents each, while the cheapest kind of suitable steel posts are 30 cents each, not including the freight. The 25-cent cedar posts last from 20 to 25 years and if inverted, 8 to 10 years will be added to their life. The average life of steel posts is likewise about 20 to 25 years.

Hence, if available, good wooden posts should be readily marketable. Black locust posts, because of their durability, should find a ready sale.

If records taken on the 71 farms constitute a representative sampling, then the yearly replacement needs of posts will be about 60,600 pieces on the 878 farms of the project area. The value of the corresponding number of white cedar posts is about $15,150.

The conclusion reached from the above facts is, that in addition to home use, some revenue can be derived from woodlands in connection with the horticultural activities in the area. The calculated amounts of timber products should be considered indicative, but not conclusive. Information concerning the yearly consumption of crates and pint and quart boxes needed in marketing of small fruits and truck farming products was not available. Likewise, the number of props used in various orchards is not know and, therefore, the yearly amount of these products needed could not be determined.

The timber requirements for posts and baskets, calculating that 50 posts are equivalent to a cord of wood and 650 feet (board measure) of lumber are needed for 1,000 bushel baskets, are as follows:

Posts	606,000 Feet B. M.
Baskets	230,000 " " "
Total	836,000 Feet B. M.

This total amount represents approximately 1,672 cords of wood and can be raised yearly at present on 3,344 acres of mature woodland. Growth data indicate that, actually, the growth of timber is taking place at the yearly rate of 0.5 cords per acre. Potentially, however, the same data show the production of timber can be doubled to reach one cord of wood per acre, provided the woodlands are stocked with proper varieties and properly managed. The area needed to produce the 836,000 feet B. M. of lumber would be reduced, under good management, to 1,672 acres.

If the 2,000 acres of timber in the project area were given the best management and care, it would supply the post and basket demand. This leaves fuelwood, saw log timber and other wood products to be grown on additional land.

Multiple use peculiar to forest vegetation.

In addition to the benefits available from the forests already described, there are other values intimately connected with the existence of woodlands. Forest provides cover and a certain amount of food for wildlife. On areas devoted to farming where most of the food needed by game is readily available on agricultural fields, the value of forest as a shelter for game is particularly important. Wildlife in woodland is not disturbed greatly by the various field operations which are necessary on agricultural land.

The esthetic value of forests, although hard to evaluate, adds considerably to the attractiveness of the landscape. This quality of the landscape is rather important in Berrien County, which serves as one of the principal gateways to Michigan's vast tourist resources.

Direct seeding.

Direct seeding was done to a limited extent, with red oak, walnut and tulip poplar. Germination and survival of the red oak and walnut have not been satisfactory, because of rodent damage. In nearly all of the tulip poplar seedings, the survival has been highly satisfactory, few counts having shown less than 75 percent survival.

Site preparation.

In field planting, shallow furrows at regular intervals on the contour proved desirable. The furrows should be spaced the distance apart it is planned to have the tree rows. This type of preparation makes a strip approximately 2 feet wide, in which there is little competition from grass and weeds.

A depth of 3 to 4 inches is considered sufficient in plowing an ordinary sod. The trees may then be planted in the bottom, or along the edge of the furrows. On the well drained soils in the project, planting in the bottom of the furrow has given good results. On poorly drained soils, planting along the edge is preferred, because it keeps the tree out of water which may concentrate in the contour furrows.

On areas where it is not feasible to use furrows, sites were prepared by scalping a fairly large spot for each tree. This system is usually more expensive than furrows and may require more hand labor to prevent excessive weed growth.

Sandy areas subject to blowing were mulched before or soon after planting, to stabilize the soil until the trees become large enough to prevent soil movement. Such areas were usually small. Prunings from fruit trees or grape vines were found to furnish sufficient protection when spread evenly over the ground (Figure 43).



Figure 43. Brush mulch used on "blow sand" protects the soil and young seedlings during establishment of the plantation. (Mich-296)

Survival of plantings.

Survival counts made on 21 farms which comprise 94 acres of the total forest tree plantings indicate that 2-2 transplants (2 years in seedbed, 2 years in lineout bed) have given the best results. Counts made on 2-0 stock showed only 53 percent survival, while 2-1 stock averaged 76 percent, and 2-2 stock averaged 82 percent survival. These records were computed for red pine, Scotch pine and Norway spruce.

In the spring of 1936, two sandy areas which were rapidly becoming "blow-outs" were planted to 4-year old transplants of red pine. Despite the dry summer which followed, 80 percent of the trees survived, indicating that red pine is a highly desirable species to use on such locations (Figure 44).

Counts made on the survival of black locust show wide variation according to soil type. Plantings on light sand or "blow-outs" have not produced more than a 30 to 40 percent stand, while survival on the heavier soils has averaged about 85 percent. Many of those trees which did survive on the sandy areas have not produced satisfactory growth and have been damaged extensively by the locust borer.

Species planted.

Various species of trees and shrubs were used on the project for reforestation and wildlife planting. The ages and number of each species used are shown in Table 5 in the appendix.



Figure 44. Red pine have done well on areas subject to severe wind erosion. (Mich-91A)



Conclusions.

Generally speaking, land having over a 25 percent slope should be maintained in woodland.

Land which has been destroyed by erosion for agricultural purposes should be reforested.

The use of windbreaks should be encouraged on areas susceptible to wind erosion. Large transplants should be used for this purpose.

In a horticultural area where there is demand for baskets, boxes, posts and other wood products, the amount of woodland needed to produce the required timber, under the present system of management, is approximately three times the area now in forest land.

Shallow contour furrows are recommended as a good site preparation practice. On well drained soils, the trees may be planted in the bottom of the furrow, but on the heavier soils, the trees should be planted along the upper edge of the furrow.

Scalping has proved as successful, but not as economical, as contour furrowing.

Fruit tree prunings may be economically used in brushing "blow" areas to be reforested.

Black locust has made the best survival and growth on the heavier soils. Red pine has made the best survival and growth on the sandier areas and blow-outs.

The survival of 2-2 red pine stock was 30 percent over that for 2-0 stock.

Woodland management.

A woodland management plan, giving recommendations for a typical farm woodland, is included in the appendix.

Wildlife

The project has never had the services of a biologist and consequently, wildlife work has not been a major activity. In an area of such a high population and intensive cultivation, the opportunity for extensive wildlife work is limited. Nevertheless, in forestry and woodland management planning, consideration of wildlife was given, particularly with respect to cover.

During the severe winter of 1935-1936, a number of feeding stations were established in cooperation with the Berrien County Sportsmans Club. Some feeding was continued by the project forester in 1937, 1938 and 1939.

LAND USE

The area designated for the project consists largely of soils which have been farmed intensively for many years. Consequently, the holdings are usually small and nearly all the land must be farmed under such circumstances. Even though some portions of a holding are poorly adapted to fruit and truck production, they are so utilized if there is any possibility of a successful harvest, since other crops will return so little. It is, consequently, difficult to persuade these growers to accept a land-use program which will remove from cultivation, any considerable percentage of their marginal land. It should be mentioned in this connection, that the favorable marketing conditions existing here raise many soils form the submarginal to the marginal and from the marginal to the supermarginal. Hence, many farms which would be retired from cultivation if more distant from markets, are retained in production here.

Despite the difficulties involved in securing the application of sound land-use under the peculiar circumstances existing on this project area, the basic plan for land use must provide that crops be grown on those sites to which they are best adapted. If this is not done, crops will be grown or marginal, or even submarginal sites, with attendant evils of low production, high cost and soil destruction.

The best land use must necessarily include other considerations: soil type, slope and present condition of erosion, whenever fruit crops are to be introduced or continued on any particular site; the relative frostiness of the site; the possibility of the occurrence of destructive low winter temperature; the relative earliness of the harvest and probably marketing conditions are all involved in reaching a recommendation. Thus, the best utilization of any specified soil type, with any given slope and erosion factors (except perhaps the steepest slopes and the most badly eroded soils) depends on its geographical location in the area, the topography of the surrounding land, marketing conditions which vary from year to year, and the extent of the particular holding. These factors cannot be superimposed on a table of recommendations without listing an excessive number of treatments for each crop and soil division. Nevertheless, in many instances, these factors must dominate the soil characteristics in reaching a sound conclusion for the utilization of any particular site.

No such table will be presented here, since "land use" recommendations, as outlined in the project work plan, may be used without serious objection until land use capability classes and recommendations have been prepared.

SPECIAL STUDIES

In applying soil conservation practices to land on the project, there arose a number of problems which were not wholly solved through existing experimental data. From necessity, therefore, certain special studies were instigated. Wherever possible, they were made in cooperation with other public agencies, particularly Michigan State College.

These studies, among others, dealt with such subjects as: the influence of continuous vegetation on insect problems in orchards; the influence of erosion control practices on farm income; the comparative value of certain practices in controlling run-off and soil losses; the effect of erosion on fruit yields; the improvement or development of certain equipment for erosion control; and the comparison of various material for mulching purposes.

Owing to the limited time since the inception of the studies, the restricted facilities of the project and the fact that each has been reported individually, these studies are not included in detail in this report.

SUMMARY

The Benton Harbor Project of the Soil Conservation Service was established during 1935 in southwestern Michigan, where the climatic influence of Lake Michigan has made fruit production the chief agricultural enterprise. It consists of two areas which were selected to include a variety of soils, types of farming and erosion conditions. Severe erosion by both wind and water is present.

The purpose of the project was to develop and demonstrate methods of controlling erosion and conserving both soil and moisture in the project, which was regarded as representative of some 3.5 million acres in the Lake Shore fruit belt.

To develop a program of work, preliminary economic and reconnaissance conservation surveys were made. Later, to facilitate execution of the program, the economic survey was enlarged and the conservation survey made in detail.

In developing the work plan, recommendations for proper land use were given first importance.

Since the chief use of land on the project is for fruit production, the establishment and observations of erosion control practices have been primarily in connection with orchard lands. Nevertheless, cropland, meadows, pastures and woodland have not been neglected.

Both vegetative and mechanical means of establishing erosion control have been utilized. On fruit lands, these have included the use of complete sod, sod and mulch, modified sod, alternate middles in sod, sod buffer strips in the tree rows, cover crops, terraces, diversion channels, contour planting and windbreaks, as well as the provision for terrace outlets, various methods for gully control, and special types of cultivation. Observations of the methods in use indicate that all have practical applications. Owing to the possibility of competition with the trees, however, vegetative methods should be modified to meet the specific conditions encountered. For obvious reasons, certain mechanical methods for erosion control are not always applicable to orchards already established and consequently, vegetative methods must be relied upon to a greater extent in such orchards.

On land not in orchards or woods, soil and water conservation have been effected by better vegetative cover resulting from an increased use of fertilizer and liming materials, improved crop rotations, more green manure crops, larger acreages of cover crops, pasture improvement and better meadow seedings. Strip cropping and contour cultivation have also been effective. In addition, terraces and diversion channels with proper outlets have been constructed and gullies have been stabilized. In general, on cropland , vegetative methods have been relied upon more than mechanical measures.

Improved management practices have been applied to existing woodlands. Numerous eroded sites, no longer suitable for agricultural use, have been reclaimed by reforestation. Reforestation of such sites is an important step in furthering the project land use program. More woodland is justified, also, to supply lumber for the manufacture of many wood products utilized locally.

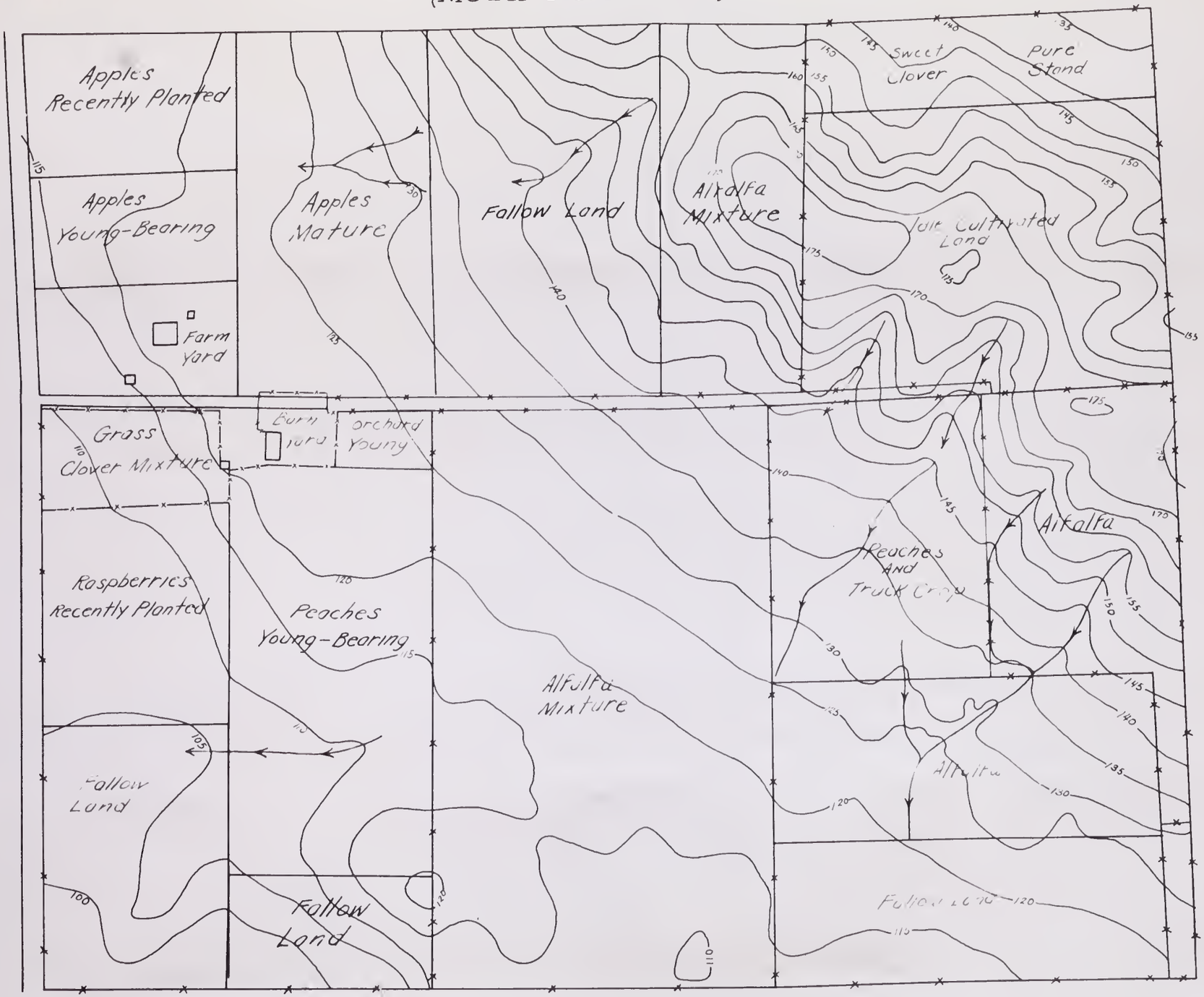
In preparing cooperative agreements, complete farm plans showing good land use have been emphasized. Future farm planning will be aided materially by the use of land capability tables and recommendations after these have been worked out.

It is well to emphasize the importance of fitting the physical measures of erosion control into the farm plan in such a manner as to enable the farmer to obtain a livelihood for his family. In short, the economic problem is equally as important as the conservation of soil and water through physical measures.

The real test of farm planning for soil conservation is the manner in which the plans work out in actual practice. A typical cooperative agreement from this project (A-Mich-1sc-50 - Lewis M. and Mildred Umphrey) is cited to bear out this observation. This farm gives a representative picture of the way various erosion control practices can be combined to make a complete farm plan. It also shows the relative ease of establishing control measures on general farming land, as compared to the gradual, long time process of rearranging fields which are in perennial horticultural crops. This farm plan, like many others, has been improved annually to include more and better methods of erosion control. The essential features of the Umphrey plan are shown in Figures 45 and 46 and the cropping plan immediately following these illustrations.

Louis Umphrey Farm

(Model Farm Plan)



Scale 1"=100'

Before Plan

Figure 45. Original field arrangement on farm of Lewis Umphrey.

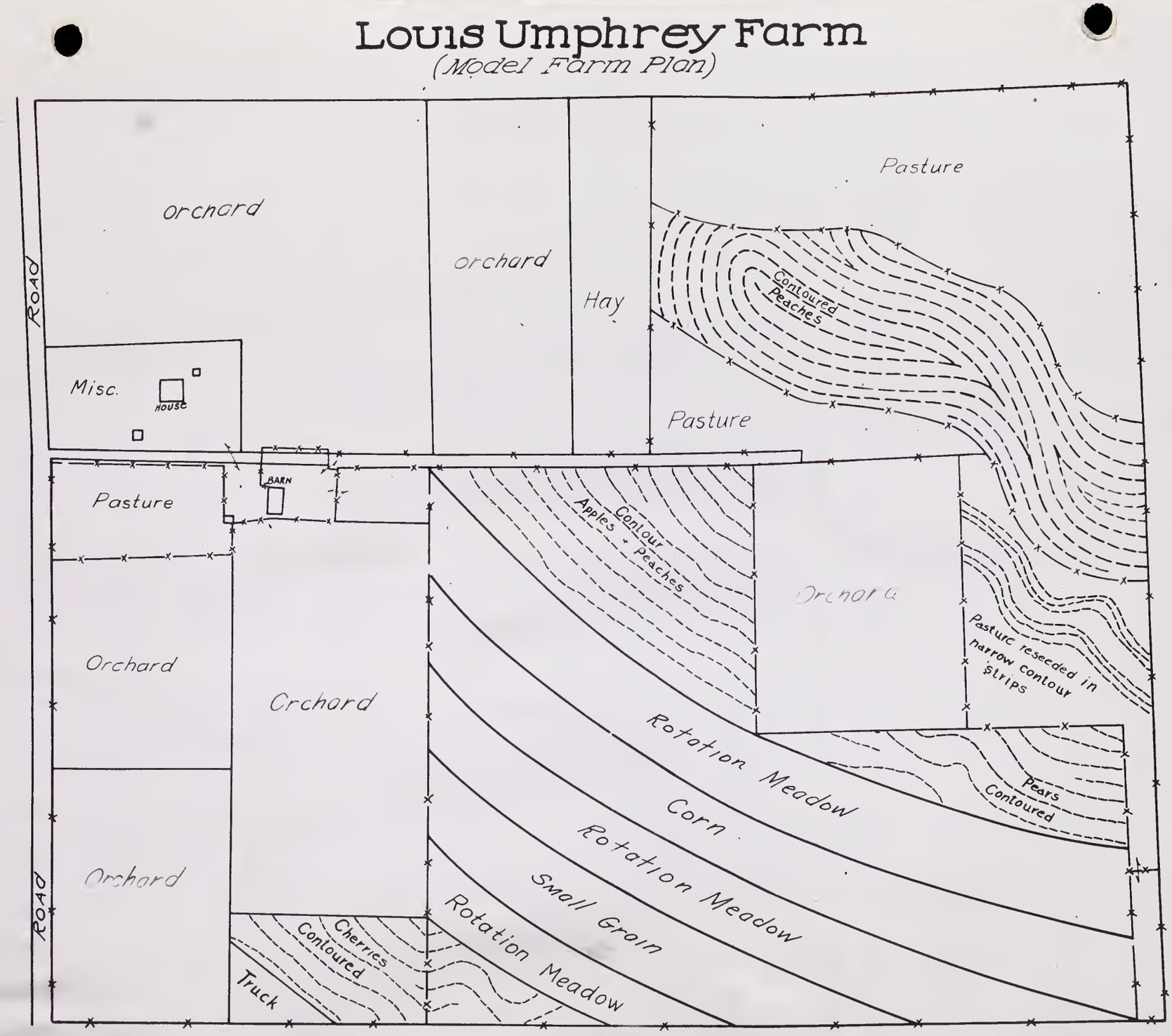


Figure 46. Revised field arrangement on farm of Lewis Umphrey.

Form Z-27

CROPPING PLAN

WORK UNIT Mich-1 FARM NO. B-5-7 SHEET NO.

OWNER Lewis M. Umphrey TENANT

Field	Strip	Acres	1935	1936	1937	1938	1939	1940
1		5.1	Apples	Apples	Apples	Apples	Apples	Apples
2		2.5	Truck	Truck	Peaches	Peaches	Peaches	Peaches
3		1.2	Truck	Corn	Alfalfa	Alfalfa	Alfalfa	Alfalfa
4		4.7	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture
5		3.1	Pasture	Pasture	Pasture	Pasture	Peaches	Peaches
6		1.3	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture
7		2.3	Farmstead	Farmstead	Farmstead	Farmstead	Farmstead	Farmstead
8		0.6	Pasture	Pasture	Pasture	Pasture	Pasture	Cherries
9		1.6	Rasp-berries	Rasp-berries	Rasp-berries	Rasp-berries	Rasp-berries	Rasp-berries
10		3.5	Peaches	Peaches	Peaches	Peaches	Peaches	Peaches
11		2.9	Alfalfa	Corn	Oats	Alf.-Brome	Alf.-Brome	Alf.-Brome
12		2.3	Alfalfa	Corn	Oats	Clover	Clover	Peaches Apples
13		2.5	Peaches	Peaches	Peaches	Peaches	Peaches	Peaches
14		2.1	Pasture	Pasture	Pasture	Pasture	Pasture	Pasture
15		2.1	Alfalfa	Alfalfa	Alfalfa	Corn	Oats	Alf.-Brome
16		1.3	Alfalfa	Corn	Oats	Alfalfa	Alfalfa	Peaches, Apples, Pears
17		1.6	Alfalfa	Alfalfa	Alfalfa	Corn	Soybeans	Oats
18		1.4	Alfalfa	Alfalfa	Corn	Soybeans	Oats	Clover
19		2.4	Alfalfa	Alfalfa	Alfalfa	Corn	Oats	Clover
20		1.4	Corn	Oats	Corn	Alfalfa	Alfalfa	Cherries
21		2.1	Corn	Corn	Corn	Truck	Cherries	Cherries

2m 3

CONCLUSIONS AND RECOMMENDATIONS

During the life of the project, numerous observations and conclusions were made concerning the methods used to prevent soil losses and conserve moisture. Final conclusions concerning many of the practices cannot be drawn until more time has elapsed and more observations made. This is particularly true concerning those applied on fruit lands. Nevertheless, insofar as is possible at the end of the fifth year of project operation, conclusions and recommendations have been recorded herein. They have been placed immediately following the various subjects analyzed and described. For ready reference to these subjects, the reader is referred to the complete table of contents appearing at the beginning of this monograph.

APPENDIX

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 Schedule #1

PHYSICAL ACCOMPLISHMENTS

Current Date: March 1, 1940
Date First Agreement Signed: May 27, 1936
Total Period Covered: 3 Yrs. 9 Mos.

Region: 3 State: Michigan Project: Mich-1, Benton Harbor, Benton Harbor, Mich.
No. Name Headquarters

Column No. (1) (2) (3) (4) (5) (6) (7) (8)

Item No.

(1) DEGREE OF PROGRAM ESTABLISHMENT

		No.	%	Acreage	%
(2)	Total Project Area Requiring Soil Conservation Treatment	2	100	36,215	100
(3)	Total Farms & Ranches in Project Area	878	100	36,215	100
(4)	Cooperative Agreements Signed	131	14.9	7,150	19.7
(5)	Cooperative Agreements in Force	122	13.9	6,645	18.3
(6)	Coordinated Program Established	128	14.6	6,976	19.3
(7)	Farms & Ranches Where Post-Agreement Cooperation May be Expected.	96	75	5,232	75

(8) LAND CONVERSIONS

(9)			AFTER AGREEMENT (ACTUAL 1939)					
(10)	BEFORE AGREEMENT		Crop land	Pasture or Range	Perma-nent Hay	Wood-land Wild-life	Orchard Vine-yard	Other land
(11)	Cropland	2176	1458	90	196	17	414	1
(12)	Pasture or Range	885	63	640	2	177	3	
(13)	Permanent Hay	162	22	6	98	1	35	
(14)	Woodland & Wildlife	385	1			372	12	
(15)	Orchard & Vineyard	2959	166	30	52	12	2689	10
(16)	Other Land	409	24	17	25	37	32	274
(17)	Acres in Agreement	6976	1734	783	373	616	3185	285
(18)	Net Changes		-442	-102	+211	+231	+226	-124

(19) SUMMARY OF ACCOMPLISHMENTS

			Potential Acreage	Actual Acreage	% Accomplish-ment
(20)	Total Project Area Requiring	C	6,976	6,976	100
(21)	Soil Conservation Treatment	NC	29,239	1,053	3.6
(22)	TOTAL	C & NC	36,215	8,029	22.2
(23)	Acreage in Project Not Requiring Soil Conservation Treatment		0		
(24)	TOTAL GROSS ACREAGE OF PROJECT		36,215		

Schedule #1

DEGREE OF PRACTICE ESTABLISHMENT

Item No.			COLUMN NO. (1)	(2) Unit	(3) Potential Amount	(4) Actual Amount	(5) % Accomplishment
			C	Acres	409	382	93
(1)	Contour Cultivation		NC	"			
			C	"	297	217	73
(2)	Strip Cropping		NC				
			C	Miles	48	48	100
(3)	Terracing		NC	"			
			C	As.Prot.	196	196	100
(4)	Terraces		NC	"			
			C	Acres	3440	3440	100
(5)	Winter Cover Crops		NC	"			
			C	"			
(6)	Basin Listing		NC	"			
			C	"	1186	1186	100
(7)	Fertilized (New Practice)		NC	"			
			C	"			
(8)	Hummocks Leveled		NC	"			
			C	"	1434	1434	100
(9)	Approved Rotations	000-000	NC	"			
			C	"	33	33	100
(10)	Contour Furrows or Ridges		NC	"			
			C	"	141	94	67
(11)	New Pasture or Range		NC	"			
			C	Number			
(12)	Farm Ponds		NC	"			
			C	As.Ft.Stor.			
(13)	Farm Ponds		NC	" " "			
			C	Acres			
(14)	Controlled Grazing		NC	"			
			C	"	1186	1186	100
(15)	Limed		NC	"			
			C	"			
(16)	Springs & Wells Developed		NC	"			
			C	"			
(17)	Water Spreading	000--000	NC	"			
			C	"	285	221	78
(18)	New Permanent Hay	000--000	NC	"			
			C	"			
(19)	Wildlife Areas		NC	"			
			C	"	197	197	100
(20)	New Woodlands		NC	"			
			C	"	6	6	100
(21)	Windbreak Plantings		NC	"			
			C	"	616	616	100
(22)	Woodland Protected		NC	"			

Schedule #1

DEGREE OF PRACTICE ESTABLISHMENT (CONT'D.)

Item No.	COLUMN NO. (1)		(2) Unit	(3) Potential Amount	(4) Actual Amount	(5) % Accomplishment
		C	Acres			
(23)	Annual Ditch Systems *	NC	"			
		C	"	84	84	100
(24)	Mulched	NC	"			
	000--000					
		C	Lin.Ft.	8194	8194	100
(25)	Diversions	NC	"			
	New Fences Built to Aid	C	Rods	2264	2264	100
(26)	In Erosion Control	NC	"			
	Fences Relocated to Aid	C	"	641	641	100
(27)	in Erosion Control	NC				
		C	Lin.Ft.			
(28)	Streambank Protection	NC	"			
		C	Rods	64	64	100
(29)	Roadsides Treated	NC	"			
		C	Number	1760	1760	100
(30)	Gully Structures	NC	"			
		C	"	4	4	100
(31)	Outlet Structures	NC	"			
		C	"			
(32)	Streambank Structures	NC				
		C	Acres			
(33)	Improved Irrigation Methods	NC				
		C	Number	1	1	100
(34)	Roadside Structures	NC	"			
(35)	RESULTS OF PRACTICES					
(36)	Acres Taken out of Cultivation	C	Acres	428	428	100
		NC	"			
		C	"	471	409	87
(37)	Decreased in Clean Tilled Crops	NC	"			
		C	"	1734	1499	86
(38)	Crop Land Winter Protected*	NC				
		C	(Animal	50	50	100
(39)	Stock Reduction on Range Lands	NC	Units)			

* Figures for latest year only.

C = Cooperator
NC = Non-cooperator

SCHEDULE
NO. 5

REPORT ON UNIT COSTS
For Fiscal Year Ending June 30, 1938

Region: 3 State: Michigan Project: 1 Benton Harbor (Name) Benton Harbor (Headquarters)

Item No.	Column No. (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)		Unit	Quantity Upon Which Unit Cost is Based	Total Cost	Percent Contributed by Coop'r	Percent Contributed by Gov't	Unit Cost for Tech. Serv.	Actual Cost per Unit	Est'd. Unit Cost to Operator
(2)	LAND USE TREATMENT								
(3)	Cultivated	Acres	223	$2216	88	12		$ 9.93	$ 9.00
(4)	Pasture	"	99	404	89	11		4.08	3.80
(5)	Permanent Hay	"	76	695	60	40		9.15	8.50
(6)	Range	"							
(7)	Woodland	"	21	194	3	97		9.24	7.00
(8)	Orchard & Vineyd.	"	442	5132	71	29		11.61	10.50
(9)	Other Land	"							
(10)	Total Acreage Treated	"	861	8641	62	38		10.03	8.96
(11)	PRACTICES								
(12)	Plans	Acres	1763	2012		100		1.14	1.00
(13)	Establishing Contour Cultivation in Orchards	"	** 59	329		100		5.58	3.00
(14)	Strip Cropping	"	104	106		100		1.02	1.00
(15)	Terracing (Orchard)	Miles	** 6.5	414	19	81		63.70	50.00
(16)	Terrace System	" Acres	** 61	414	19	81		6.79	6.00
(17)	Cover Crops	"	32	81	100			2.53	2.53
(18)	Listing or Basin Listing	"							
(19)	Contour Furrows or Ridges	"							
(20)	Planting New Pasture	"	31	232	90	10		7.48	7.48
(21)	Farm Ponds	Ac.Ft.							
(22)	Planting Permanent Hay	Acres	120	952	88	12		7.94	7.94
(23)	Planting Wild life Areas	"							
(24)	Planting Trees	"	33	280	17	83		8.48	7.00
(25)	Annual Ditch Systems	"							
(26)	Mulched	"	84	1646	100			19.60	19.60
(27)	Diversions	Lin.Ft.	650	13		100		0.02	0.02
(28)	New Fence Construction	Rods	233	315	15	85		1.35	1.00

Small units and complex systems of farming have tended to increase costs.

** For fiscal year ending June 30, 1939.

SCHEDULE 6

GENERAL, ADMINISTRATIVE, AND INFORMATIONAL DATA
Up to March 1, 1940

Current Date: March 1, 1940.
Date First Agreement Signed: May 27, 1936.
Total Period: 3 Yrs. 9 Mos.

Region: 3 State: Michigan Project: I (No.) Benton Harbor (Name) Benton Harbor (Headquarters)

GENERAL

Counties affected: Berrien

Problem area:

The Benton Harbor Project was set up as a demonstration of erosion control practices for the "Lake Shore Fruit Belt." This belt consists of a strip of land extending along the eastern shore of Lake Michigan from Petoskey to the Indiana state line. The total area includes approximately 3,500,000 acres.

The soils are derived from glacial outwash, glacial till, and beach sands. The principal series include Coloma, Emmet, Bellefontaine, and Plainfield. The topograpy is undulating and rolling to hilly in some of the larger dune sections.

Wind erosion is a serious problem throughout the entire area. Sheet erosion, with a loss of 75 to 100 percent of the surface soil, has affected one-half of the area. The remainder shows a loss of 25 to 50 percent of the topsoil. The growing season varies from 140 to 160 days and rainfall averages 28 to 34 inches.

The crops grown consist primarily of cherries, peaches, apples, and truck crops.

Date project approved: July 1, 1935.

SCHEDULE 6

GENERAL, ADMINISTRATIVE AND INFORMATIONAL DATA (CONT'D.)

ADMINISTRATIVE

Fiscal Year	Technicians	Clerks	Regular Laborers	Foremen
1935	15 8/13	4 12/13	26	1
1936	13 3/4	4 5/12	25 7/24	1
1937	11	3 11/12	25 5/24	1
1938	10	3	22 1/3	1
1939	8 1/12	3 2/3	9	1
1940	4	1	4 2/3	0

Total man-days W. P. A. labor 4049

Total man-days CCC labor none

Functional organization chart showing flow of authority to project.

To be supplied at Regional Office.

Camps administratively attached to project.

None

SCHEDULE 6

GENERAL, ADMINISTRATIVE, AND INFORMATIONAL DATA (CONT'D.)

INFORMATIONAL

No. visitors to project: 1,482

No. radio programs, by stations: None

No. farmers meetings: 81

Estimated attendance: 3,750

No. farmer tours: 75

Estimated attendance: 1,000

No. student tours: 25

Estimated attendance: 500

Principal interested newspapers:	Average circulation:
News Palladium, Benton Harbor	12,000
Herald Press, St. Joseph	6,000
Niles Daily Star, Niles	3,500
Berrien County Record, Buchanan	2,000
Watervliet Record, Watervliet	1,200
Community Enterprise, Bridgman	2,100

No. movies shown: 32

Estimated attendance: 1,500

No. miles of sign-marked highways within project: 15

Ave. daily auto traffic along such sign-marked highways: 6,195

No. pieces printed literature distributed: No record

No. CCC students in off duty courses: None

No. exhibits shown: 51

Estimated visitors at exh.: 60,000

Station	Precipitation in Inches during Number of Minutes Stated																
	Minutes														Hours		
Michigan	5	10	15	20	25	30	35	40	45	50	60	80	100	120	3	6	12
Alpena	.59	.94	1.11	1.25	1.57		1.60	1.68	1.77		1.85						
Detroit	.78	1.37	1.81	2.06	2.21	2.36	2.46	2.51	2.59	2.60	2.98	3.47	3.78	3.86			
Grand Haven	.42	.72	.89	1.04	1.28	1.43	1.54				1.67	2.02					
Grand Rapids	.48	.89	1.10	1.31	1.51	1.71	1.86	2.01	2.11	2.19							
Houghton	.48	.79	.99	1.16	1.35	1.44	1.68	1.87	2.10	2.26	2.61	3.29	3.80	4.28			
Ludington	.52	.82	1.10	1.24	1.38	1.51	1.71	1.96	2.14	2.28	2.50		2.84	3.22	3.75		
Marquette	.48	.74	.96	1.16	1.42	1.67	1.93	2.18	2.34	2.50	2.93	3.54					
Port Huron	.46	.74	1.05	1.35	1.60	1.86	2.10	2.28	2.32							2.58	
Saginaw	.62	.93	1.11	1.22								1.26					
Sault Ste.Marie	.61	.85	.92	.94	1.01	1.10			1.12	1.15	1.17	1.35					

Table 2. Maximum rates of precipitation at each station through 1933. Rainfall is shown in "inches."

	2 Years	5 Years	10 Years	25 Years	50 Years	100 Years
5 Min. Rainfall	0.40	0.45	0.50	0.50	0.60	0.60
10 Min. Rainfall	0.62	0.75	0.88	0.88	1.00	1.12
15 Min. Rainfall	0.75	1.00	1.12	1.20	1.25	1.50
30 Min. Rainfall	1.00	1.25	1.50	1.75	2.00	2.00
1 Hr. Rainfall	1.25	1.50	2.00	2.25	2.75	2.75
2 Hr. Rainfall	1.25	2.00	2.25	2.75	3.00	3.50
4 Hr. Rainfall		2.50	2.50	3.00	3.50	4.00
8 Hr. Rainfall		2.50	3.00	3.50	4.00	4.50
16 Hr. Rainfall		3.00	3.00	3.50	4.00	5.00
24 Hr. Rainfall		3.00	3.50	4.00	4.00	5.00

Table 3. Rainfall intensity frequency data for southwestern Michigan, as compiled from maps from U. S. D. A. Miscellaneous Publication No. 204.

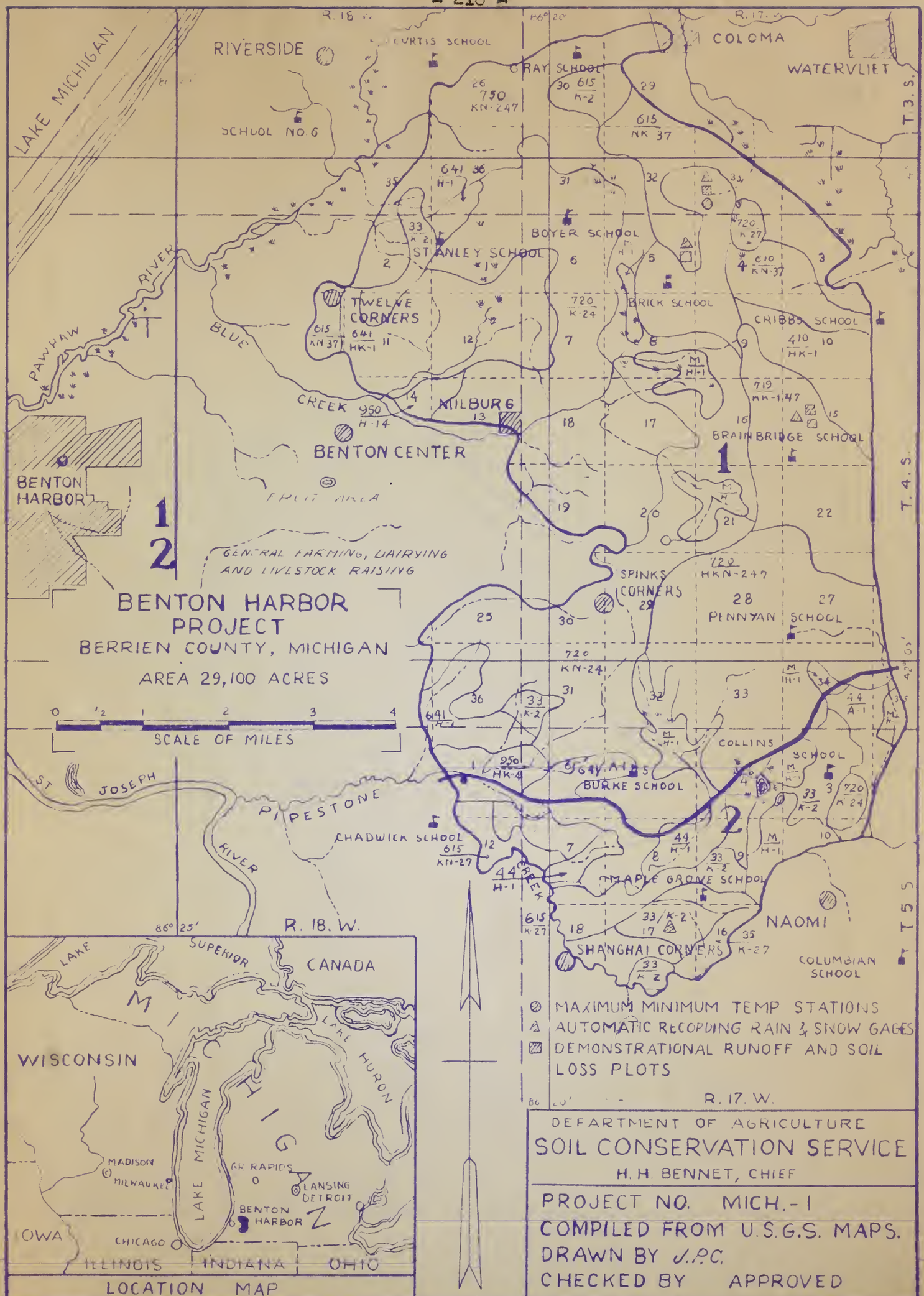


Figure 47 Reconnaissance Soil Conservation Map. Millburg Area

RECEIVED
FEB 10 1931

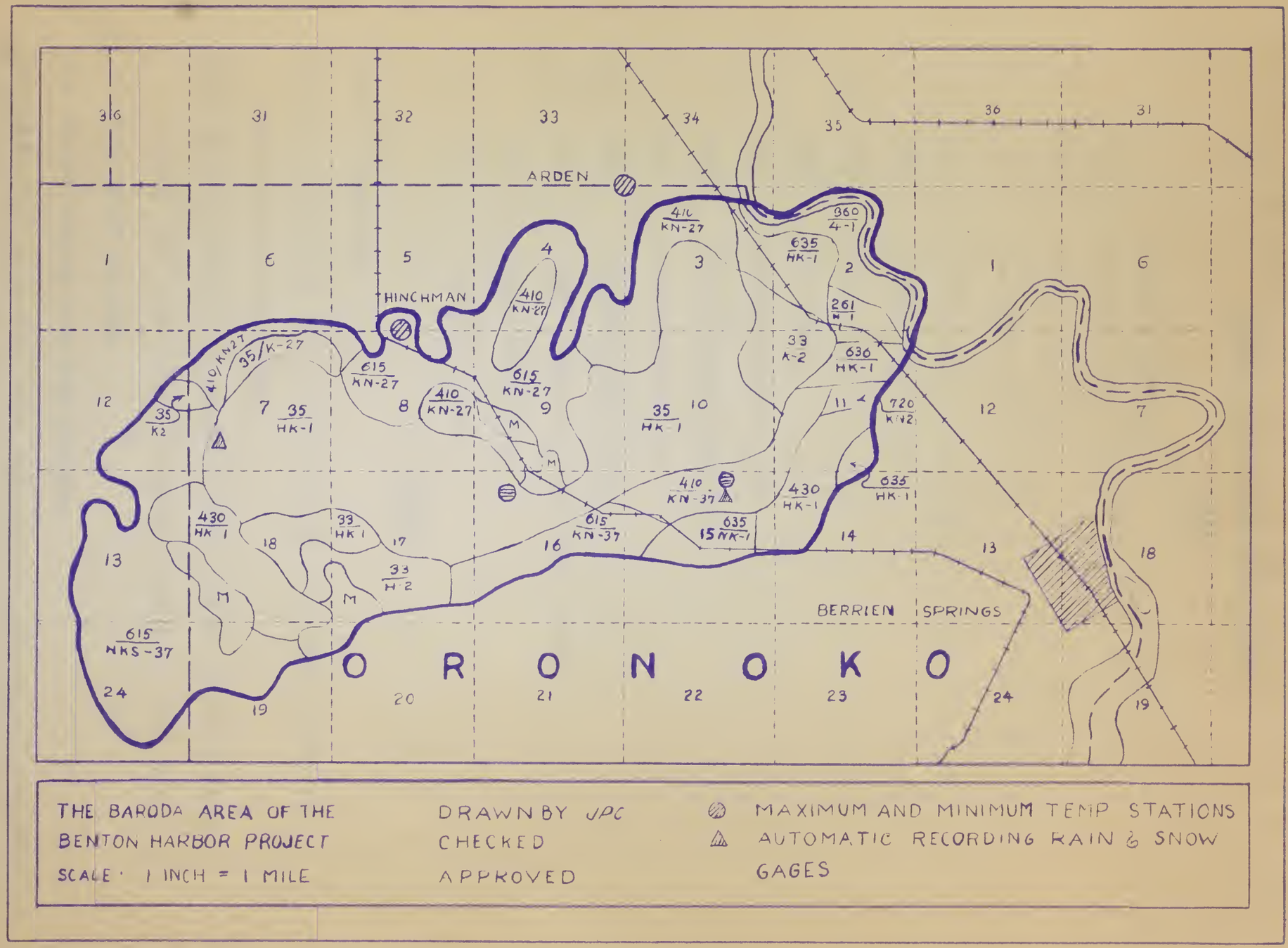


Figure 48 Reconnaissance Soil Conservation Map, Baroda Area

FEB 10 1931

LEGEND FOR RECONNAISSANCE MAPS

SOILS

4	Mucks and Peats
33	Nappanee Silt Loam
35	Miami Silt Loam
44	Brookston Loam
261	Griffin Silty Clay Loam
360	Genessee Silt Loam
410	Hillsdale Loam
430	Fox Loam
610	Hillsdale Sandy Loam
615	Bellefontaine Sandy Loam
635	Oshtemo Sandy Loam
641	Allendale Sandy Loam
719	Coloma Lomay Sand (Retentive phase)
720	Coloma Loamy Sand
950	Plainfield Sand

SLOPES

H - 0 - 5 percent.

HK - Over 50 percent of area from 0-5 percent slopes, remainder mostly from 5-10 percent.

HKN - About 50 percent of slopes in area ranging from 0-5, about one-fourth of area from 5-10 percent slopes and the remainder from 10-20 percent.

K - Slopes ranging from 5-10 percent.

KN - More than one-half of area composed of slopes ranging from 5-10 percent. Most slopes of the remaining area ranging from 10-20 percent.

SLOPES (Continued)

NK - Most of area comprised of slopes ranging from 10-20 percent in association with predominately 5-10 percent slopes.

EROSION

1. Slight to moderate sheet erosion, usually less than 25 percent of the surface soil removed.

14. Slight to moderate sheet erosion combined with slight to moderate wind erosion.

147. Slight to moderate sheet erosion, slight to moderate wind erosion and occasional gullying, mostly less than four feet deep.

27. Moderate sheet erosion and occasional gullying.

247. Moderate sheet erosion, slight to moderate wind erosion, and occasional gullying.

37. Moderate to severe sheet erosion, (usually more than 50 percent of the surface soil removed), combined with occasional gullying.

A. Erosion and slope conditions.

1. Northern, or Millburg, Area of the Benton Harbor Project.

The following data is based upon a detailed reconnaissance survey of the area:

SLOPES		DEGREE OF EROSION	
H -	6022 Acres	1 -	5342 Acres
HK -	2977 "	2 -	2520 "
HKN -	2977 "	27 -	1075 "
K -	4928 "	37 -	1644 "
KN -	4617 "	14 -	877 "
NK -	3166 "	147 -	1148 "
		24 -	7543 "

Total general area affected by wind erosions - 12,423 acres.

Refer to Figures 47 and 48 and legend for interpretation of above symbols.

2. Southern, or Baroda, Area of the Benton Harbor Project.

SLOPES		DEGREE OF EROSION	
H -	775 Acres	1 -	3712 Acres
HK -	2939 "	2 -	465 "
K -	738 "	27 -	1235 "
KN -	1460 "	37 -	1628 "
NKS -	1128 "		

Refer to Figures 47 and 48 for legend to above.

Table 4. Summary of results of soil conservation survey.

B. Predominant Soil Types.

1. Modification of Soil Survey of Berrien County, published in 1927, was used as a basis for the following information.

a. Northern, or Millburg, Area.

SOIL TYPES	ACRES
Nappanee Silt Loam	1332
Nappanee Loam	179
Miami Silt Loam	117
Hillsdale	2131
Bellefontaine Sandy Loam	1700
Coloma Loamy Sand	4940
Coloma Loamy Sand (Smooth Phase)	8748
Plainfield Sand	980
Allendale Sandy Loam	1809
Brookston Loam	729
Newton Silty Clay Loam	58
Mucks and Peats	282

b. Southern, or Baroda, Area.

SOIL TYPES	ACRES
Nappanee Silt Loam	576
Miami Silt Loam	1942
Bellefontaine Loam and Hillsdale	819
Bellefontaine Sandy Loam	1753
Fox Loam	576

b. (Con't.)

SOIL TYPES	ACRES
Oshtemo Sandy Loam	472
Newton Silty Clay Loam	58
Newton Loam	26
Genessee Silt Loam	301
Griffin Silty Clay Loam	115

LIME REQUIREMENT MAP OF BERRIEN COUNTY, MICHIGAN

(Based upon Soil Survey by Michigan Agricultural Experiment Station and U. S. Bureau of Soils)

None to Slight Acidity

0 to 1 TON LIMESTONE PER ACRE

Slight to Medium Acidity

1 to 2 TONS LIMESTONE PER ACRE

Medium to Strong Acidity

1½ to 3 TONS LIMESTONE PER ACRE

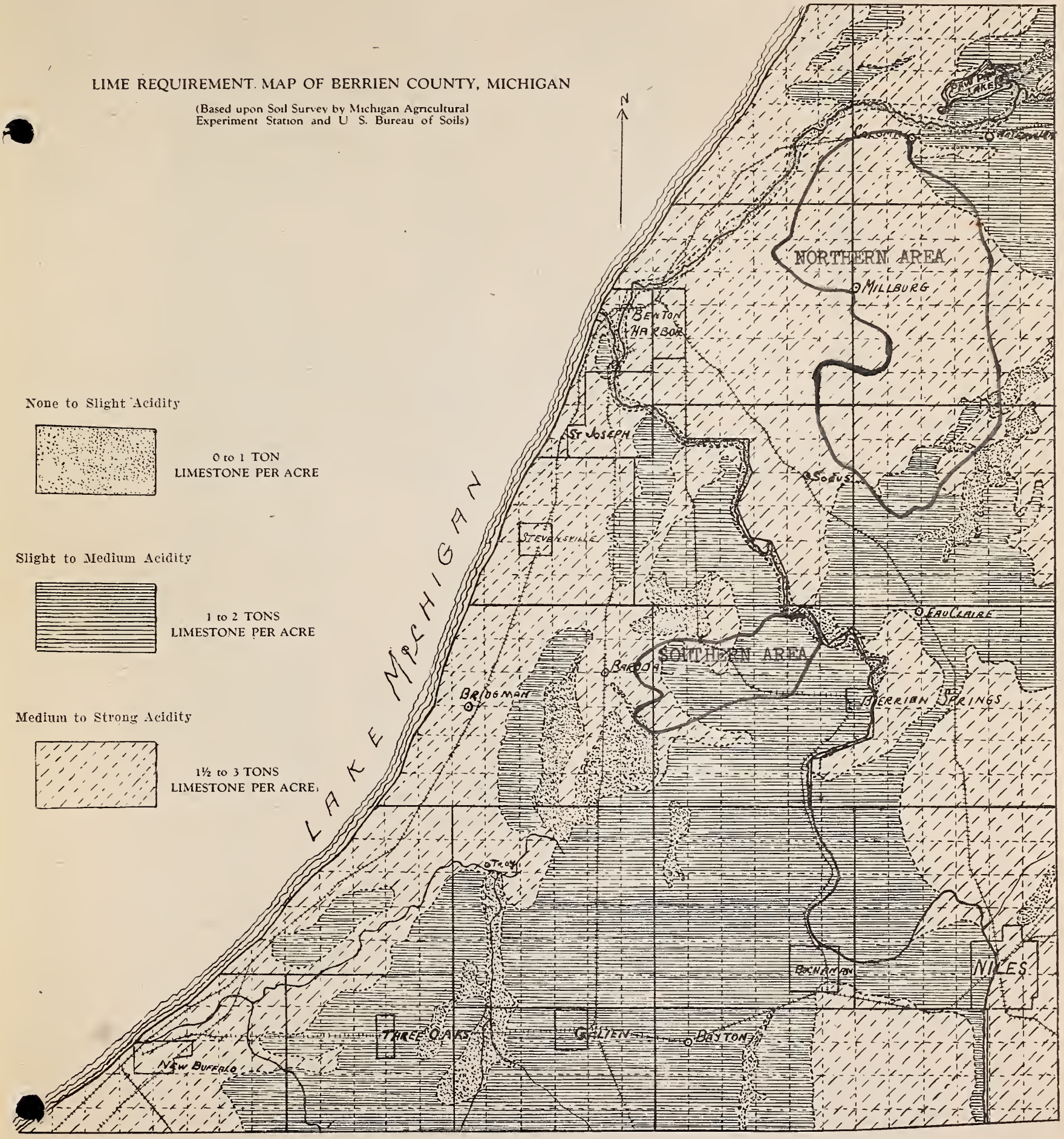


Figure 49.

The soybean grows well on soils that vary widely in lime content. It is doubtful if any of the soils in the county are too sour or acid for the successful production of this legume. This, of course, means that a soil building crop and a forage crop of high feeding value may be obtained without the use of lime.

The non-legumes or grains, grasses, and some of the vegetables afford less returns from the application of lime and larger profits from the proper use of fertilizers than do alfalfa or the clovers. If the soil is quite sour or acid, however, they respond directly and very profitably to lime as well as the fertilizer. As a general rule, lime is most beneficial to these crops indirectly; that is, by the establishment of alfalfa or clovers, the value of which is well known.

Land for the production of tree and bush fruits does not need lime except when unusually sour, or for the production of legumes for cover crops. The strawberry is very tolerant of soil acidity. It is generally conceded that lime should be applied to the land following potatoes rather than just previous because the potato scab producing organisms thrive in a sweet soil.

The vegetables **not sensitive** to acid soils are watermelons, radish, squash, turnip, potato and parsley. The vegetables **slightly sensitive** to acid soils are corn, rhubarb, endive, Brussels sprouts and beans. The vegetables **moderately sensitive** to acid soils are carrots, tomatoes, cucumbers, pepper, cabbage, pumpkins and peas. The vegetables **highly sensitive** to acid soils are cauliflower, muskmelon, parsnips, eggplant, asparagus, onion, beets, celery, spinach and lettuce.

Finely ground limestone is more profitable than coarse. Marl, and sugar beet refuse lime, where available, are usually profitable forms of lime to use. If one is unable to purchase a carload of lime or cannot do so jointly with his neighbor or neighbors, and is too far away from marl to obtain this material cheaply, it may be advisable to use hydrated lime.

THE MAP

The map is necessarily generalized because of the scale employed. It is not implied that all of the soil in any one area has the degree of acidity indicated, but simply that a certain soil condition is true in general. Numerous small bodies of land affording exceptions may be found.

The degree of acidity or sourness of the soils, as outlined on the map, indicates the amount of lime required to bring the soil to the best condition of productiveness, particularly for alfalfa and the clovers. An exact figure for the amount of lime required cannot be given because of the various factors which have to be taken into consideration, such as the kind or cause of the acidity, the crops to be grown, the nature of the soil type and the kind of lime used.

The Soils Section of the Experiment Station at East Lansing, Michigan, and County Agricultural Agents are ready to examine samples of soils, and to give more specific advice and recommendations in individual cases.

Circular Bulletin No. 58 April,

AGRICULTURAL EXPERIMENT STATION
MICHIGAN AGRICULTURAL COLLEGE

East Lansing, Michigan

Lime for Berrien County Soils

By

M. M. McCOOL and J. O. VEATCH

Lime is the keystone to the production of clovers and alfalfa on sour s One of the first benefits resulting to the farmer from the recent co-oper soil survey of Berrien County by the Michigan Agricultural Experi Station and the United States Department of Agriculture is the map of the lime requirements for the entire county. Thousands of acre southwestern Michigan soil are either non-productive or are not produ profitably, because, through lack of lime, the above legumes cannot be gr This soil survey, coupled up with lime and fertilizer experimental w should accomplish a great purpose in aiding to make the agricultur Berrien County a more profitable enterprise.

The accompanying map shows the lime situation with respect to Be County soils. There are 29 soil types in this county. In this report have been placed in three groups, depending upon their lime requirem The final and complete report on the soils of this county, to be publish the near future, will show in complete detail the locations of the diff types together with their description, composition, needs, and other condit

It is to be noted that the different groups of soils in this county ha rather wide range in their lime needs; that is, they vary from nothing high lime requirement. The lime deficient soils, in large part, accoun the relatively low percentage of cultivated land devoted to alfalfa and cl which was 3.5 per cent in 1919. An ideal condition is maintained when a one-third of the cultivated land comprising the lighter soils and one-fo of the heavy soils is devoted to some legume; that is, where one does not mainly on commercial sources for nitrogen. If the acreage of alfalfa clover is to be materially increased, lime in some form must be used gene

It is true that nearly all farm crops are sensitive to deficiencies of that is, their development is retarded when the lime content of the s sufficiently low. Yet there are great variations in the tolerance of cro lime deficiency. The most sensitive of the legumes is alfalfa, foll closely by sweet clover. Vetch, June, and Mammoth clover have a some lower lime requirement, while alsike, although it does best on soils tha well supplied with lime, grows on soils th re too sour for the other clo

KIND	AGE	NO. THOUSANDS	(BU.) SEED	CUTTINGS
Arborvitae Oriental	1-1	.538		
Ash, Mountain	1-0	.200		
Barberry, Japanese	1-0	.200		
Barberry, Japanese	2-0	.200		
Buffalo Berry	1-0	.500		
Caragana	1-0	1.500		
Caragana	1-0-1	.200		
Catalpa	1-0	3.000		
Cedar, White	2-1	.200		
Cherry Bush	1-3	.085		
Cherry, Choke	1-0	.800	2	
Chestnut, Chinese	1-0	.600		
Chestnut, Chinese	2-0	.700		
Coral Berry	3 Plus	1.425		
Coral Berry	4 Plus	.800		
Cornus femina		.100		
Cottonwood	1-0	.300		
Dogwood, Gray	1-0	.450		
Dogwood, Gray	3 Plus	1.300		
Dogwood, Red osier	1-0	.500		
Hazel, American	1-0	.800		
Hickory, Pecan	1-0	.100		
Honeysuckle Bush	1-0	.100		
Lilac	1-0	.600		
Locust, Black	1-0	54.460		
Locust, Black	1-0-1	12.940		
Locust, Black	1-1	21.880		
Maple Sugar	1-0	.300		
Mulberry, Red	1-0	.500		
Mulberry, White	1-0	1.700		
Oak, Bur	1-0	5.070		
Oak, Bur	1-0-1	1.000		
Oak, Pin	1-0	.300		
Oak, Red				1
Oak, Red	1-0	13.480		18½
Oak, Red	2-0	.060		
Oak, Swamp White	1-0	.500		
Oak, Swamp White	2-0	.350		
Oak, White				1½
Oak, White	1-0	.200		
Olive, Russian	1-0	.450		

Table 5. Summary of tree planting on the project area.

KIND	AGE	NO. THOUSANDS	(BU.) SEED	CUTTINGS
Pine, Austrian	2-0	3.840		
Pine, Austrian	2-1	.695		
Pine, Austrian	2-0	1.135		
Pine, Red 1/	2-0	12.300		
Pine, Red 1/	2-0-1	2.000		
Pine, Red	2-1	16.315		
Pine, Red	2-1-1	.040		
Pine, Red	2-2	19.425		
Pine, Red	2-2-1	31.480		
Pine, Scotch 1/	2-0	2.300		
Pine, Scotch	2-1	11.150		
Pine, Scotch	2-2	.250		
Pine, Western Yellow	2-0	1.200		
Pine, Western Yellow	3-0	2.540		
Pine, Western Yellow	3-1	.170		
Poplar	3 Plus			3.700
Poplar, Yellow	1-0	2.000	10	
Poplar, Tulip	1-0	4.750		
Poplar, Tulip	2-0	.600		
Poplar, White	1-0	.300		
Red Bud	1-0	.200		
Rose, Prairie	1-0	.100		
Spruce, Norway	2-0	.500		
Spruce, Norway	2-1	11.650		
Spruce, Norway 1/	2-1	.900		
Spruce, Norway	2-0-1	.945		
Spruce, Norway	2-1-1	.525		
Spruce, White	2-0	2.595		
Walnut, Black	1-0	7.100	9 8/15	
Walnut, Japanese		.030		
Willow	1 Plus			1.500
Willow	3 Plus			4.490
Total 42 species		263.040	42 8/15	9.690

1/ These trees furnished by cooperator. All other furnished by S. C. S.

All trees planted by S. C. S.

Table 5. - continued

Typical Woodland Management Plan

Introduction.

In the Cooperative Agreement which you entered into with the U. S. Department of Agriculture, Soil Conservation Service, you agreed to protect the woodland in Field 1a from fire and grazing and to harvest all woodland products in the future on a selection basis.

The Government, in their part of the Cooperative Agreement, agreed to do timber stand improvement on one acre and to furnish you with a simple plan for management of your woodland, in order that maximum production may be obtained from your woodland.

What you have.

Your 4.25 acres of woodland consists of a stand of mixed oak (red, black and white oak), hickory, black cherry, with an understory of dogwood.

An inventory of the timber in your woodland, in which all trees 6 inches in diameter and over were measured (diameters measured at 4.5 feet from the ground) indicates 35 standard cords per acre, or a total of 150 standard cords. (A standard cord is a pile of wood 4 feet wide, 4 feet high and 8 feet long). The saw timber volume for trees 14 inches in diameter and over is as follows:

	On 1.0 acre	On 4.25 acres
Black oak	8,000 bd. ft.	34,000 bd. ft.
Red oak	500	2,125
White oak	200	850
Black cherry	40	170
Hickory	300	1,275

This makes a total of 9,040 bd. ft. per acre, or 38,420 bd. ft. on the 4.25 acres. The saw timber volume was computed on the basis of using the International Log Rule ($\frac{1}{4}$ inch saw-kerf) and deducting 10 percent for cull.

Grazing of your woodland in the past has resulted in lack of reproduction (small trees and seedlings) and a slower growth rate than if protected. Protection and proper methods of harvesting (removal of vines, decadent trees and trees showing lack of vigor) will make available space for young, desirable trees and should result in an increased growth rate.

What you need.

Taking the size of your farm buildings into consideration, a reserve of timber should be kept at hand to take care of periodic emergency needs for farm buildings amounting to 20,000 bd. ft. Your annual needs for woods products include: 8 standard cords of fuel wood, 20 posts, 400 bd. ft. lumber, and 2,000 bd. ft. for fruit packages. These annual needs expressed in one unit are equivalent to 13 standard cords. Due to the fact that oak is not usually used for fruit packages, your annual needs can be put at 9 standard cords.

Growth studies made in your protected woodland indicate that it is growing 2.5 standard cords on the 4.25 acres. Since your annual requirements are 9 standard cords, you are depleting your growing stock at the rate of 6.5 standard cords per year. It may be possible, under intensive management, to bring your growth rate up to 6 standard cords for Field 1a but until that time, you will have to depend on the grazed woodland in Field 1b for the remaining 6.5 standard cords to fill your annual requirements. Field 1b now contains approximately 270 standard cords for all trees 6 inches in diameter and over.

How to manage your woods.

This plan analyzes your need for woodland products, material available to meet this need, and outlines recommended practices to guide you in the future treatments of your woodland. The objectives of management are designed to keep your woodland permanently and increasingly effective for soil and water conservation, to maintain a reserve supply of high quality timber to replace or repair buildings, to provide a perpetual annual supply of wood products for home use, and to increase the annual growth to the maximum of which the site is capable.

Some general recommendations are set forth below to assist you in attaining the objectives listed above:

1. Continue to protect your woodland from fire and grazing (Figure 50.)



Figure 50. Natural reproduction is limited in pastured woodlands. Mature and decadent trees are all that remain. (Mich-43)

2. When harvesting trees, always use the selection method. This means the removal of trees of large diameters that show lack of vigor or are "going back", dead, defective, and trees of poor form (crooked and knotty trees which never will produce high quality saw timber) and all vines growing on trees. Save the young trees of desirable kinds to produce high quality timber for future cuttings. When trees are cut, they should be felled so that minimum damage will be done to trees that are left. Cut stumps low and utilize low grade logs, branches, tops for posts, fire wood, etc. All material too small to use should be cut up and scattered so it will lie close to the ground. This material is an important source of organic matter that should not be destroyed by burning.

3. When cutting logs, the trees should be cut up so as to secure as many straight, clear logs, free from defect, as possible. It is usually advisable to place the logs on skids or blocks if they are not removed from the woodlot immediately after cutting. Fire wood should be piled on skids to prevent its contact with the soil and permit air circulation to secure proper seasoning. Fuel wood that is thoroughly seasoned or "dried" will produce from 50 to 60 percent more heat than green wood. This seasoning requires approximately one year. Fence posts of durable woods should be peeled and piled so they will season well before setting. Non-durable woods may be treated with some preservative to make them last longer after setting in the ground. If zinc chloride treatment is used, the posts must be green with the bark left on. Creosote treatment should never be applied unless the posts are peeled and thoroughly seasoned.

4. A border or margin of 30 feet should be left around your woodland. No cutting should be done in this border, other than that necessary to salvage timber from being wasted. This border serves as a windbreak for the interior of the woods.

5. In addition to the seed and seedlings planted by the Soil Conservation Service, it may be necessary to do some more planting if good, natural reproduction does not come in soon enough in openings which will occur. Sugar or hard maple, red oak, white oak, black walnut, and whitewood (tulip poplar) are recommended for planting.

Specific recommendations outlined below are designed to bring about maximum growth capacity on every acre of woodland in the least time possible.

1. During the winter of 1939-40, remove vines, dead, down, and deformed trees from the woodland in Field 1a. After this 1939-40 period, if vines or trees with defects as described above appear, they should be removed.

2. During the winters from 1940-41 through 1945-46, cut only enough trees to total 2.5 standard cords. These should be trees of large diameters, that show lack of vigor and any defective or deformed trees. If trees 16 inches in diameter and over are removed, it will require approximately 4 to 5 trees to yield 2.5 cords. If your annual needs are less than indicated, or it is taken care of by woods from other fields, the annual cut should, of course, be decreased. Specified cutting plans beyond 1945 can be worked out at that time. Those plans will take into consideration the growth rate, amounts, and condition of the timber at that date.

3. In order to secure desirable reproduction in sufficient amounts, it will be necessary to control the growth of dogwood so it will make up only a small percentage of the stand. Information on suggested ways of control will be given you at a later date.

The small size of your woodland and the fact that you will need all the wood your woodland will produce, makes the sale of woodland products of minor importance. However, if a case arises for sale of timber, there are a number of good, local markets where timber can be sold.

It is doubtful if the 4.25 acres will ever grow enough annually to take care of your annual needs, so it would seem highly desirable to protect at least two more acres of the woodland that are now grazed. The woodland in Field 1a, however, should increase in growth and supply a share of your annual needs for woodland products.

Woodland Records.

Woodland records should be kept along with your other farm records, as part of the farm business. A suggested form is attached.

HARVESTING RECORD

PRODUCTS

Time or Cutting	Area Cut	Saw Logs		Fuel Wood		Posts			Others			Value or Price Rec'd.
		Bd. Ft.	Hours Labor	Standard Cords	Hours Labor	No.	Size	Hours Labor	No.	Size	Hours Labor	

Notes on Gully Control

Ramser's (8) curves for Region 3 were used in determining run-off, except for watersheds over 50 acres. On larger watersheds, the Rational formula (8) was used to calculate run-off. Channel sizes were at first designed as given under terrace outlets and later, the tables and curves (1) given at the February conference for E. C. W. and S. C. S. engineers were used to determine channel sizes, except for watersheds over 50 acres. These larger channels were designed by using Manning's formula (1). Tables, based on the formula $Q = 2.5\ LH^{3/2}$ were used in determining the size of weir notches for dams. The design of flumes and drop inlets was based on the work of Lewis Kessler (2) of the Wisconsin Engineering Experiment Station, the notes on flume design by R. B. Hickok (5) and King's Handbook of Hydraulics (6).

Notes on Design and Use of Gravity Dams

1. Gravity dams are designed as retaining walls.

2. Batter is placed on the upstream side so that a better seal is established between soil and concrete. Downward pressure of soil minimizes cracking away of the soil from the concrete face. Upstream batter also gives better protection from ice thrusts.

3. Gravity dams are used as gully plugs where gullies are especially deep and narrow and when land values are high, one large gravity dam will reclaim more area than a series of small check dams.

4. Gravity dams can be built economically only where large quantities of boulders or rock are available. Boulders up to two feet in diameter may be used in the bottom.

5. A great saving of cement can be made if rocks are placed in layers and concrete poured around one layer at a time.

6. Steel fence posts, or similar steel, can be used for the little reinforcing needed.

7. Forms are simple to build.

8. Apron and wing extensions are poured after forms are stripped from the gravity section. They are anchored to the main section by placing rods or steel fence posts into the dam when it is poured.

Notes on Use and Design of Arch Dams

1. Arch dams bring nearly all stresses in concrete into compression; the result is a great saving in steel.

2. Abutments may be made massive; boulders may be used as aggregate, if they are available.

3. A hinged arch allows for movement in abutments, due to settling or frost action.

4. The arch type weir wall minimizes the hazard of failure around the end of head wall extensions, due to the fact that it is curved upstream and some of the storm water is actually going over the weir wall before it reaches the head wall extension. This relieves the head wall extension of considerable hydrostatic pressure.

5. The forms necessary to construct an arch dam are naturally rather complicated, but they may be used over and a greater variation in size of dam can be obtained by using these forms than can be obtained by using almost any other type of form for check dams.

6. Because of the high cost of constructing a true hinged arch, a modified hinge was used on the project. It consists of reinforcing used as doll bars and a sheet of corrugated sheet iron as a separator.

7. This arch type dam is especially adaptable to use in wide waterways, such as terrace outlets, where the steel required in a standard check dam would be maximum.

8. In the construction of this dam, the abutments are poured first. The arch wall is poured after forms are stripped from the abutments.

9. Arch slabs are poured on a footer. No attempt is made to establish bond between footer and arch wall.

10. Apron is poured last after back-fill is made around arch wall. This reduces vertical beam action of arch slabs to a minimum. A further precaution against beam action would be made on larger dams by using a 1 inch mastic joint between apron and arch slabs.

Notes on Orchard Terracing

History of orchard terracing.

The first terraces on orchard land were built by the Soil Conservation Service in the spring of 1937, on the Roy Butzbach farm, in Bainbridge Township. These were built as level, closed-end terraces. It was felt, at that time, that the maximum amount of moisture should be conserved because of the drouthy nature of the Coloma loamy sand, which was the soil type terraced in this case. The terraces were designed and located to hold a total rainfall of 4 inches in 24 hours, on frozen ground. They were located by a trial and error method on a contour map before being staked out in the field. The design called for an absorptive type terrace (built from both sides) with a ridge height of 18 inches. Inasmuch as this was the first terrace job attempted on the sandier soils of the area, some difficulty was experienced in moving the sandy soil. Consequently, the terraces, when finished, were too high and too narrow to be maintained satisfactorily. Under cultivation, the effective height of the terrace has been reduced approximately 4 inches. These terraces have not been severely tested to date because the terrace channels and terrace intervals have been maintained in alfalfa. Cultivation has been performed only along the tree rows which were located on the terrace ridges or parallel to the ridges in the terrace intervals.

Two other orchards were terraced during 1937 on Coloma soil types. The spacing of these terraces was governed by the standard spacing of terraces (12) for the North Central States. One and one-quarter miles of level open-end terraces of the absorptive type were constructed on the J. D. Bury farm in Benton Township. Because of the deep, sandy soil and a hummocky conditon caused by wind erosion, considerable difficulty was experienced in constructing these. The two factors which caused most of the difficulty were first, the inability of the No. 1 terracing machine to move the sand laterally, and second, the occasional sinking of the steel terracer wheels into the soft, sandy subsoil. As a result, this terrace job was not considered first-class and it was believed uneconomical to spend the time that would be required to perfect it with the available equipment.

The third terrace system, built during 1937, was rather small. Only two terraces, approximately 400 feet long, were built on the Emil Jaffke farm in Bainbridge Township. The maximum spacing was used for these terraces. That is, the standard spacing, plus 20 percent for contour cultivation of the terrace interval. The top terrace channel had a variable grade ranging from 0.2 percent at the upper end to 0.4 percent at the lower end. The lower terrace was constructed with a uniform grade of 0.2 percent. No particular difficulty was encountered in constructing these terraces, as the subsoil was not as sandy as that previously encountered. More examples of early orchard terracing could be given here, but the three given will suffice to furnish the background around which the improvements in orchard terracing were made.

Terrace maintenance (letter to cooperator).

Dear Cooperator:

TERRACE MAINTENANCE BY PLOWING AND DISCING

Terraces must be supported by correct tillage and cropping practices in order to be maintained. The most desirable practice for terraced land is contour farming -- the plowing, discing, and planting of crops parallel to the terraces. This produces a series of small depressions and ridges and these aid in moisture conservation and erosion control. By plowing parallel to the terraces and regulating the location of dead furrows and back furrows, terraces can be maintained and their cross-sections or shapes changed so as to provide the most desirable slopes for any particular field.

The method of locating dead furrows and back furrows as shown in the attached illustration 1/ is considered best for orchard and cropland terraces in the Benton Harbor area. In many cases where orchards are set to peaches, there will not be sufficient space to carry out the third step as shown in the illustration without much loss of time in turning. It is suggested that after Step 2 of the illustration is completed, the remaining land be disced out by working parallel to the terraces; that is, the land left after the channels have been plowed out and back furrows thrown up to the short or point rows which are not terraced.

1/ Illustration referred to is Figure 15.

If the plowing is to be done by team, it is suggested that a one horse plow, equipped with a short whippletree, be used in making the first two or three rounds next the trees. If a tractor is used, the plow hitch should be off-set as far as possible toward the tree row. In this way, plowing may be done fairly close to the trees without injuring them.

Methods other than the one illustrated may be used if the terrace channel is in good condition. One other such method is simply to back-furrow to each tree row and terrace ridge and plow around until land between rows or terraces is plowed out. In maintaining cropland terraces, the location of dead furrows and back furrows between terraces should be varied somewhat annually.

Terraces may also be maintained by discing -- if a single disc is not available, use only the front half of a tandum disc. The disc should be set so as to work the ground away from its center. The disc should be operated parallel to the terrace ridge so that the soil is worked up toward the trees, or the top of the ridge, allowing one-half of the disc to run in the terrace channel. On a return trip, again allow one-half of the disc to run in the channel and the other half to move the soil up the terraced back slope, away from the terrace channel.

Terrace outlets.

At the outset, both artificial and natural outlets were designed by using Manning's formula (1) for a maximum velocity of 3 feet per second. Later, this designed velocity was raised to 4 feet per second. Flat bottom channels, having side slopes of three to one, or four to one, and having a minimum depth of 18 inches, were generally used as specifications for designing these channels. After approximately 10 outlets were designed for watershed areas up to 15 acres, a check was made with the table of dimensions for terrace outlets, as compiled by Calkins (11) and also the curves given by Cook (1). Although the table did not check exactly with the designs worked out, the difference was not enough to affect the velocity materially. For watershed areas up to 15 acres, outlets were designed by using Calkin's tables and Cook's curves. For larger watersheds, the design was worked out by using Manning's formula. Run-off was determined by using Ramser's (8) run-off curves for terraced areas, based on a 10-year frequency.

Terracing equipment.

During the winter of 1938, the steel wheels on the No. 1 Caterpillar terracer were replaced by Chevrolet truck wheels with 6 inch pneumatic tires. A block of concrete weighing 300 pounds was also added to the rear of the machine. These changes made a great improvement in the operation of the machine, on both the light and the heavier soils. The wheels no longer cut into the subsoil and there was less side slippage.

Other types of equipment used on the project in the terracing of orchard land consisted of small equipment which was used primarily in terracing established orchards. A Corsicana terracer was used considerably for this type of work. It did not work satisfactorily at first on the sandier soils for the same reasons which were given for the No. 1 terracer with steel wheels. Early in the summer of 1938, two wheelbarrow wheels, equipped with heavy duty, 4-inch tires, were substituted for the standard steel coulters. To adapt the new wheels, their hubs were reamed out to permit each to fit over the outer hub of a coulter carriage. The two flanges of a coulter carriage were then placed together and a wheelbarrow wheel fastened to the outside by bolting through the flanges of the coulter carriage and the hub of the wheelbarrow wheel. A 0.5 inch bushing was used to keep the tire from rubbing on the coulter cleaner carriage. A picture of this improved machine is shown in Figure 51.

Pneumatic tires greatly improved the usefulness of this machine. Better control of the depth of cut was obtained and less side slippage occurred on both sand and heavy soils. When the heavier soils were wet enough to cause serious side slippage, they were usually too wet to be terraced without puddling the soil. The rather long blade adjustment levers of the Corsicana terracer were frequently struck by low hanging limbs, causing a sudden change in the depth of cut.



Figure 51. Corsicana terracer equipped with 14 by 4 inch heavy duty wheelbarrow tires and wheels. The use of rubber tires has improved the operation of this machine on both sandy and heavy soils. (Mich-540)



Two Slusser and McLean terracers, equipped with pneumatic tires, were purchased for use on the project area. The screw depth adjustment on these terracers eliminated the problem encountered in orchard work with the lever adjustment type terracer. The Slusser and McLean terracers have not been used extensively to date, but inasmuch as this machine is still in the experimental state, a few improvements which should be made are noted here. The screw adjustment should be changed so that the adjustment operation could be speeded up and better thrust bearings at the end of the screw shaft should be provided. The Slusser and McLean machine has been found to be superior to the Corsicana in dirt moving ability. This may be due to the increase in weight over the Corsicana, or the design of the terracer blade.

Recently, the screw adjustment has been replaced by a lever type adjustment on the Slusser and McLean terracer. The levers are shorter and a more positive lever quadrant has been provided than on the Corsicana. Consequently, their use in established orchards should not be objectionable. However, since this change has been made, the terracer has not been used in orchard work.

Two V-drags were built and used on the project. Their use was confined to terrace maintenance or the building of terraces in established orchards. The sizes of these drags were 6 by 12 feet and 7 by 14 feet. The length of the short leg, or mold board side, is given first and the long leg, or land side board, is given last. These drags were constructed similar to the dimensions given by Ramser (9). Their weights were 250 pounds and 850 pounds, respectively. The larger of these drags was equipped with one-quarter inch by 3 inch Z iron runners, and its short leg was covered with sheet iron to reduce soil friction. Two sizes were built so that the cooperator could use the one best suited to the tractor or horse power available. The smaller V-drag has proved successful in maintaining sand terraces when used with a team. The larger V-drag proved to be too heavy for the ordinary 2-plow tractor. This larger drag has been cut down so that its dimensions are practically the same as those given for the lighter drag, but it has not been used since this was done.

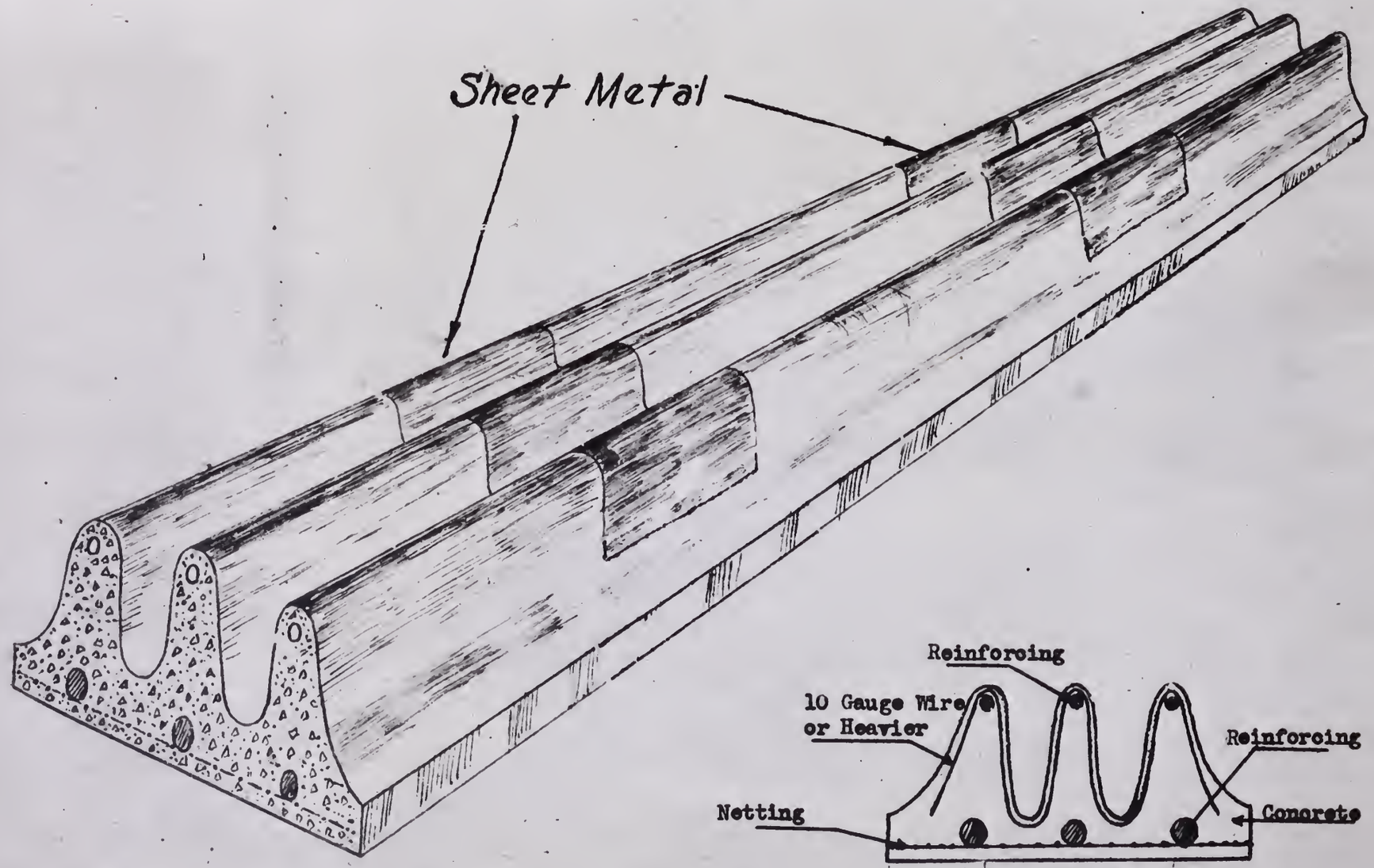


Figure 52.- Precast reinforced concrete surface drain. Sheet metal treads may be omitted. A single groove precast reinforced concrete drain can be similarly constructed by using metal drain Figure 53 as a form. These drains may be built in sections and dowelled together.

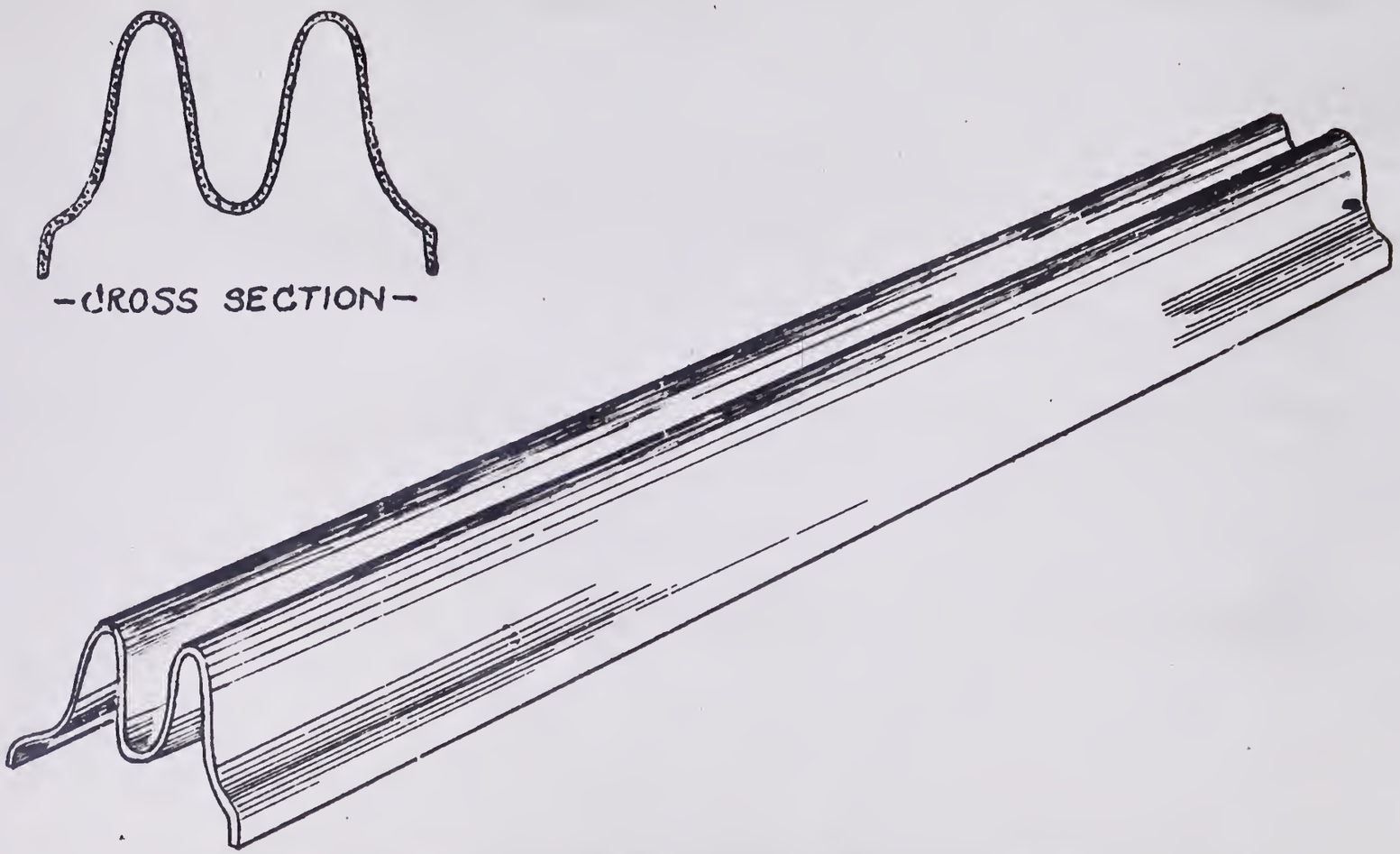


Figure 53. . Metal type surface drain made of 12-gage galvanized sheet iron. This drain may be used as a form for precasting reinforced concrete drains.